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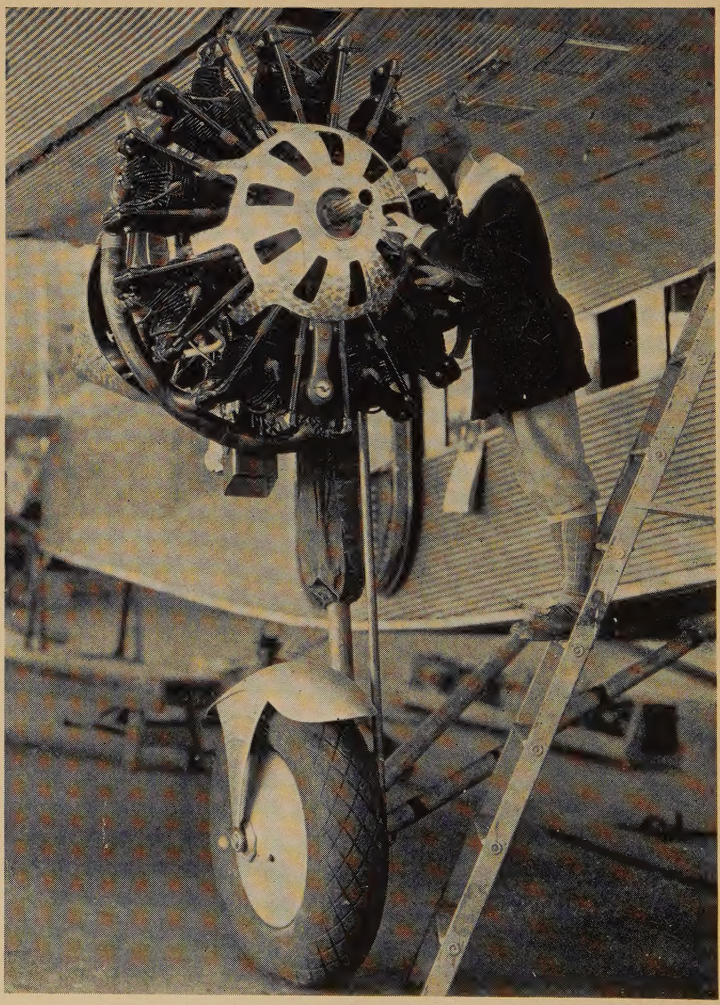
FROM THE GROUND UP

By WILLIAM A. SIMONDS

HENRY FORD: MOTOR GENIUS

By WILLIAM A. SIMONDS
AND FRED L. BLACK

FROM THE GROUND UP



A peek at a Wasp radial motor

FROM THE GROUND UP

By
William A. Simonds
and
Fred L. Black

FULLY ILLUSTRATED

DOUBLEDAY, DORAN & COMPANY, INC.
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FROM THE GROUND UP

CHAPTER ONE

THE LAMP OF ALADDIN

PAT CALLAHAN scraped the few remaining flakes of ice cream from his dish—it was marble ice cream, chocolate, vanilla, and strawberry—and laid down the spoon with a contented sigh. Such a feast! Turkey and cranberries, oyster stuffing, escalloped potatoes, sweet potatoes dripping with honey, nuts, delicious apple pie, and rich devil's food—he couldn't even recall the rest.

It was the third banquet he had eaten at the Birch Hills Country Club. Once each year the members made up a "pot" and gave the caddies a spread, an event looked forward to with much gusto and long remembered. It was the chief topic of conversation about the caddy house for months in advance. Pat had special reason to remember this one.

The chairman of the Members' Committee was a downtown business man, Mr. McDonald. It was his duty to announce the award of prizes at the conclusion of the dinner. As he rose to his feet his youthful guests leaned forward in eager attention.

"The first award of the evening," he began, "is that

for winning the caddy championship. As you all know, it was won by Patrick Callahan. Patrick, will you please come forward?"

Bedlam broke loose as Pat rose slowly from his seat. On both sides of the center table boys cheered and whistled. They all liked Pat.

Among the caddies Pat was known as a "square shooter." He was a quiet lad, blessed with a calm disposition that was seldom riled. It helped him in his game, for he had learned to keep his head no matter how stiff the competition. In the finals for the cup he had been matched against an older and more experienced player. The fellow really should have won, had he not "blown up." Pat's steady, careful strokes overcame the longer, more erratic drives of the other.

But this does not mean that Pat was dull or unimaginative. As his name indicated, there was plenty of hot Celtic blood in his veins. In fact, some folks laughingly said that his face was like the map of Ireland.

There was another reason for his popularity—he had a keen sense of humor. He liked a joke, no matter whom it was on, himself or the other fellow. His smile was quick and infectious. And when the time came to scrap he could put up a wonderful battle.

As he walked up to the club chairman he blushed rosily, embarrassed by the applause of his mates. His legs seemed as if they were made of lead, they dragged so. Pleasant prickles ran up and down his spinal column.

Mr. McDonald stepped back and from an assistant

took a handsome golf bag containing a set of brand-new clubs. It was a gift to make any boy's mouth water.

"It gives me great pleasure," he declared, "to present this set of clubs to the caddy champion of our club."

The room whirled about Pat, and the lights dazzled and danced above him. He steadied himself against the table, waiting until the shouts died down.

"Speech! Speech!" yelled the boys. The chairman held up his hand for silence and looked smilingly at the flushed face.

"How about it, Pat?"

Pat found his voice.

"Thank you, Mr. McDonald," he stammered.

He turned to his friends and lifted up the bag so that they could see it more clearly.

"Thank you, too, fellas."

Louder grew the clapping, but he shook his head. The words simply would not come. In the commotion, he stumbled back to his seat, where he bowed again and then sat down.

Other prizes followed—for the longest driving distance, for the lowest putting score, and so on. Speeches were next. The "pro" spoke; so did the caddy master and the members of the committee. The reply for the caddies was made by one of the boys who happened to be on the school debating team and who had been chosen to make the formal response.

After the final words had been spoken and the boys were filing out Mr. McDonald stopped Pat.

"Come to the office for a few moments," he invited. "We've got something more for you."

The boy's eyes sparkled. He knew that the club committee did more than give prizes and arrange a banquet for the caddies. The men took an interest in boys who showed signs of leadership. More than one of his friends had been given a boost that could not have been obtained in any other way. Tommy Ruggles had been taken into an office; "Red" McQueen had been given a chance at a technical education; Don Carter had a job in a manufacturing plant. And there were others.

Pat knew all this. It was one of the club traditions. His heart beat a trifle faster as he went forward to the office. He surmised what was coming, and he had made up his mind what to ask for. Pat wanted to learn how to fly.

His desire was a natural one, for he lived near Detroit, a city which is one of the centers of the world in aviation, just as it is in automobiles. He saw airplanes daily, flying hither and yon across the sky. He saw many famous aviators of the world when they came to Detroit to visit the airplane factories.

Like every adventure-loving boy, he wanted to learn the secret of getting up in the air so that in time he might have his share of the great adventures that are possible to knights of this new era.

Pat realized that between the ground, on which his ancestors had walked for thousands of years, and that

magic leap which would carry him off into space gifted with an ability none of them had possessed, must come a period of study and training.

Boy-like, he read all the books he could find in the school library and in the public library. He pored over the long columns in the daily papers, drinking in the thrilling exploits of the world's major aviators. He built model airplanes and flew them in the field near his home. But after a time all this no longer satisfied him. He wanted to fly.

His parents had not been able to give him much assistance. His father was a gardener and during the day worked on the grounds of the Country Club, where Pat caddied.

Inside the manager's room the members of the committee were waiting for him. They shook hands with him solemnly. Several congratulated him on his victory.

"Now, men," the chairman interrupted, "let's get down to business. We take a special interest in our caddies, Patrick, as you know. We've always done so. We like to help our boys to get ahead, especially when they show signs of wanting to help themselves."

The boy nodded and waited anxiously for the chairman to go on.

"Each year we ask the winner of the championship what his ambition is. We try to start him on the road, in other words, give him a boost. If there is something we can aid him to attain, we do it."

He smiled down into the boy's eager eyes.

"What is your wish, Patrick? What do you want? Now, don't be bashful. We're ready to help you if we can."

Pat drew in a deep breath. It had come at last. It was as if Aladdin's lamp had been handed to him so that he could rub it and make his longed-for dream come true.

"If you don't mind, sir," he answered slowly, "I want to learn how to fly."

The men stared at each other and then at Pat. They were surprised, to put it mildly. When they were boys such an idea had never entered their minds.

"Great Scott!" someone ejaculated. "How old are you, Pat?"

"Thirteen," he replied. "But I'll be fourteen soon."

Of all the wishes that had been voiced by caddies since this custom had been started, this was the most unusual.

"Well, Mac, that's a new one," laughed Mr. Haines, a young banker who already had one caddy in his bank. "Aren't you aiming rather high, son?"

"I think we'd better leave this one to the chairman," slyly suggested Frank Newell, another member. "He's the only high flier on the committee."

"That's not fair, men," protested Mr. McDonald. "I've helped every year. You all know it. What's the idea of deserting me now?"

"I certainly don't know anything about the flying

game," declared a gray-haired member. "Now, if it was in the contracting and building game . . ."

Despite these remarks, Pat's face did not betray any signs of discouragement. He grinned good-naturedly and answered their questions without a tremor. He had unlimited faith in these men.

"Don't you think you're too young to learn to fly?" asked Mr. Haines.

"Why, no, sir. Birds learn to fly before they even leave their nests."

"That's right," agreed Mr. McDonald. "Don't let them talk you out of it, Patrick."

"Wouldn't you rather get a job and learn a business?"

"That's what I want, Mr. Haines. I'm sure there're lots of jobs for flyers. Look at Lindy."

The banker shook his head in amused defeat.

"I give it up. If the lad wants to learn to fly, there's only one thing left for us to do. I'm for helping him."

The chairman nodded approvingly.

"That's the spirit. I'll get the lad started myself. But someone will have to tell me how. Where do we start, Pat? Can't you give us a few suggestions?"

The boy had his reply ready. Victory, he knew, was won, and he was tremendously happy.

"Yes, sir. I think I can. I ought to begin at the bottom. Don't you think so?"

The men looked at each other. Several pairs of eyes twinkled.

"Quite so," said Mr. McDonald. "Er—m-m-m—yes,

that's wisest, Patrick. I suppose it's up to me to find out where the bottom is. We'll start from there."

A few moments later the men bade Pat "Good-night" and walked out to their cars. It was settled that Mr. McDonald was to make the first attempt. He asked Pat for his telephone number.

"I'll call you up, my boy, as soon as I'm ready," he promised. "It may take a few days. But don't worry. This flying business is new to me. I've got to do a little investigating."

"I won't get worried, Mr. McDonald. I'm sure you can get me started. Do you know any airplane engineer? Maybe he would talk to me."

The man slapped his knee.

"Do I? I'll say I do. I should have thought of him before—W. B. Mayo. He's chief of the aviation division of the Ford company, you know. Right here in Dearborn. He ought to be able to tell us where and how to start. I'll call him up to-morrow."

CHAPTER TWO

A PEEK AT A BIG BUSINESS

PAT'S home was a small white cottage near the outskirts of Dearborn, that flourishing city which has developed along the main traveled road between Detroit and Chicago. Between the road and his father's cottage was a large truck garden, the apple of his dad's eye. The elder Callahan loved shrubs and flowers, and after working hours spent most of his time in his own garden.

Within a radius of a few miles from the cottage were several flying fields, airports, and airplane manufacturing plants. Pat could see planes in the sky at almost any hour during the day. Big transports carrying freight and passengers from one metropolis to the other flew directly overhead.

Several times each year an event of importance was held at the airport, and Pat was present whenever he could get away from his caddying. But like the other spectators, he always had to stand back of the ropes and was never able to see as much as he desired.

One Saturday during the previous winter, after the golf clubs had been put away, he had taken a bus to Oakwood Boulevard and walked down to the Dear-

born Airport. It was cold and blustery, and the December wind was blowing a gale. But he was so lost in wonder at the interesting sights that he didn't mind the cold.

Giant trimotor monoplanes and smaller biplanes stood side by side in the hangar. The dazzling lights were reflected back from gleaming metal wings or from those of lustrous, brightly lacquered fabric. He envied the men who bustled about. They clambered over the planes as if it were all in a day's work. It was then that he had resolved to learn how to fly.

He was on his way to Citizenship Class on the morning following the banquet when a young woman from the principal's office stopped him in the hall.

"Here's a hurry telephone call for you, Patrick."

She handed him a slip, and his heart gave a sudden leap.

"Call Mr. McDonald as soon as possible."

"Gee!" he exclaimed. "Hot dog!"

Forgotten was the class. He hurried to the telephone.

"Hello, Patrick," came his friend's voice, "I called your home, and your mother told me how to reach you. Can you get away from your classes for a few hours?"

"Why—er—yes, I guess so," stammered Pat, much elated.

"I've just talked with Mr. Mayo. He'll see us if you can get here before noon. After lunch he's going to Washington, D. C., and then to New York City. He'll

be away for several days, and I think we had better catch him while we can."

"All right, Mr. McDonald. I'll come over right away. The teachers will excuse me."

"O. K. Where shall I pick you up?"

"Can you meet me at the corner of Monroe Street? In front of the drug store?"

"Yes. Hurry along."

About fifteen minutes later Pat, as in a dream, found himself standing beside his friend at the threshold of a busy office that occupied one corner of a handsome white building facing an artificial lagoon, beyond which stretched the boulevard that led toward Detroit. While they waited in the anteroom, Mr. McDonald pointed out for Pat, through the glass, the figure of Mr. Mayo in the center of a group of men. His hair was silvery white, but his eyes were youthful and keen. He spied Mr. McDonald shortly and waved a hand in greeting. Soon afterward the conference broke up and the two visitors were admitted into the inner office.

"I'm glad to meet you, Patrick," said Mr. Mayo, with a quizzical smile. "So you want to learn how to fly?"

The boy grinned back. Somehow, he didn't feel a bit embarrassed in the presence of this man.

"I'd like to—very much," he replied earnestly.

"Well, I'm not surprised. Most young fellows are thinking about the same thing. Which part of the business are you especially interested in?"

"Why—er—" began Pat, doubtfully, "I don't know. Flying has been the only thing I thought about."

Mr. Mayo chuckled.

"When the Wright brothers first began," he answered, "flying *was* all there was to it. But things have changed greatly since then. Aviation to-day is—well, it's a *big* business."

"Then I was right," said Pat. "When I was talking to the men at the Country Club I told them I thought there were lots of jobs a fellow could get if he knew how to fly."

"All of the jobs are not flying jobs," Mr. Mayo went on. "Many of them offer splendid opportunities—in fact, aviation to-day is full of opportunities."

Pat was surprised. Like most boys, he had assumed that flying was the principal part of aviation.

"That statement surprises you, does it? Perhaps, if I explain, you'll understand me more clearly. Perhaps, also, you'll be better able to decide which branch you prefer. First of all, of course, comes the business of manufacturing the airplanes. Designers and engineers are needed, also production men, and, finally, sales and advertising men. You understand all that, of course. It has to come ahead of everything else."

The boy nodded.

"I knew you had to make the planes first," he agreed.

"Secondly, we must have landing fields and airports for the planes to use when they are on the ground. They can't stay up in the air all of the time. You may not

know it, but the business of building and managing airports has been growing very fast during recent years."

"Is it a good branch of aviation?" asked Pat. "I mean, does it offer many opportunities?"

"Indeed it does. It includes engineers who are specially qualified to lay out and build airports. That's a business all by itself. The job of managing an airport is a real one, requiring men with experience. They must be trained to the special needs of air traffic."

He paused for a moment, and then went on:

"Under the managers are different departments, such as that of mechanical repair. In the same way, the job of keeping track of the weather and making reports each day requires men trained in that special work. And lately we have added the radio service."

As Pat listened, his eyes grew wider and wider. He had not realized that there was so much involved in an airport. Mr. Mayo reached across his desk and picked up an air line folder.

"Now we come to the third branch, if you can call it that. Besides manufacturing airplanes and managing airports, there is the business of operating air lines over the country. And of course, trained men are needed in that work. Pilots are required to fly the planes, but in addition there must be men to manage the lines. Passengers go from city to city, and the job of directing the traffic and looking after all the details is even bigger than that of the actual flying."

"I didn't know that the air lines did so much business," Pat murmured.

"It would surprise you. In 1926 the transport companies carried about fifteen hundred passengers. In two years they increased that twenty-five times. In the same period the mail carried increased more than ten times."

"Whew!" exclaimed the boy. "I'll say it's a business!"

"In most of the jobs I've mentioned," Mr. Mayo added, "a knowledge of flying is a big asset. The man who is a qualified pilot, other things being equal, has the edge over the man who can't fly. But we still have other branches of the business to consider."

"What are they, Mr. Mayo?"

"Well, there are the companies who manufacture engines, propellers, and other special parts for airplanes. There are companies which are using airplanes for sales or advertising purposes. Each of them requires someone to direct the department as well as to fly the planes. Some private companies such as mining companies have their own planes and use them in their business. They must have some one who knows enough about the planes to direct the aviation end of their business. The list extends on almost indefinitely. And then, aside from these fields, there are two more that I haven't even mentioned."

"I know," Pat spoke up. "One of them, anyway. It's the job of navigating."

"Yes," smiled Mr. Mayo. "But I was thinking of the army and navy. Even if you don't consider them as a business, they do open the door to wide opportunities for the young man."

Pat drew in a deep breath.

"Gee, there's lots more to aviation or learning to fly that I even dreamed," he confessed.

"There are no less than nineteen different branches or fields of work in aviation. The Daniel Guggenheim Fund for the promotion of aëronautics has divided them into four general classes. Engineering, mechanical, executive, and, finally, piloting. It would be a good idea for you to remember those. Now," said Mr. Mayo, pushing back his chair, "how many times have you ridden in an airplane?"

Pat's eyes shone. He surmised what was coming.

"Not once, Mr. Mayo. My folks can't afford——"

"So you haven't had a chance, eh?" Mr. Mayo finished the sentence for him. "How would you like to take your first ride with me right now?"

"Gee, Mr. Mayo, do you really mean it?"

"Surest thing you know. How about you, Mr. McDonald? Would you like to come along? We'll make just a short trip. Say, twelve or fifteen minutes?"

Pat's friend nodded a quick assent.

"I'm always glad to go up in the air," he said. "I'd like this trip especially, since it's to be Pat's first flight."

"All right, then. Come along."

CHAPTER THREE

FLYING WITH MR. MAYO

MR. MAYO stepped to the corner of the anteroom and donned his hat and coat. A few seconds later they were seated in his sedan on their way to the airport. It was not far distant, and as they rolled up to a long, wide building that seemed like a vast barn they saw in front of it a trimotor plane, beautiful as a bird.

"This is the hangar," Mr. Mayo explained. "You know all about such things, I suppose?" he asked, while his eyes twinkled.

"I'm beginning to think I don't," the boy laughed. "But I thought I did. It's a place where airplanes are kept, isn't it?"

Mr. Mayo nodded.

"Sometime you must investigate one. But not now. Our plane is waiting. Here we are."

As the car stopped the driver slipped from behind the wheel and came around to open the door. Pat crawled from his seat, as in a dream, and followed the two men across the concrete runway to the gigantic bird. Its motors had already been started, and they were humming merrily.

Pat was greatly excited. He knew that those broad

wings were nearly eighty feet across from tip to tip, and that the plane itself was almost fifty feet long. He had read enough about these huge transports to know that there were many different kinds and models of the trimotored type. This one, Mr. Mayo told him, carried fifteen passengers besides a pilot and mechanic and had a high speed of one hundred and thirty-five miles an hour.

They had now reached the door of the cabin, which had been opened for them by an attendant. Up in the cockpit, framed in the window, Pat had seen the face of the pilot who was to take them up.

One after another they stepped up. Pat found himself in a comfortable passenger cabin with handsome leather-upholstered chairs on either side of a center aisle. The latter extended forward to the doorway leading up to the pilot's compartment. It all reminded him somewhat of a "swanky" railroad car.

"Sit down here," directed Mr. Mayo, motioning to the seat beside himself. "You can move around if you want to, so as to see better, but I'm going to make one rule—" he smiled—"no more questions now. I want you to settle back and enjoy this ride just as if you were a passenger going aloft from one city to another. Later on you'll have plenty of chances to talk to pilots and find out *how* they make the planes fly."

The suggestion was just what Pat needed. He relaxed at once.

"Don't forget," added Mr. Mayo, "that flying is

something new under the sun. Our generation is the first that has ever been able to fly. Mankind has always wanted to make a highway out of the air, but we are the first ones to see this desire of the ages fulfilled."

He spoke so solemnly that Pat was much impressed. From outside came the roar of the motors as the pilot tried out each of the three large radial engines and checked their operations.

"I'm going forward soon," Mr. Mayo added, "and you can have the seat to yourself. Look out of the window and enjoy the ride. You will be moving twice as fast as the fastest express train. After we are up in the air, open the window slightly and thrust out your fist a short way to feel the wind. Then open up your hand and hold it against the air at an angle."

The blocks (or chucks) were removed from in front of the great wheels and the plane taxied slowly along the runway. It swept along smoothly as an automobile until it reached the spot from which the pilot wished to start his take-off. At this point, as it was turning about to face the wind, Mr. Mayo arose to go forward. He patted his young companion on the shoulder.

"Enjoy yourself, now, and see how easy it is."

Pat smiled across at Mr. McDonald and turned to look out the window. They were rolling swiftly over the ground. No, they were off the ground. It was dropping away below them. They were rising above the hangar, the trees, the white ribbon that was the boulevard.

Up and up they climbed and then banked around to

circle over the field. Pat sat with his eyes glued to the window. The ground seemed like a checkerboard below. The houses ended and the countryside appeared. Long black lines showed where the railroad tracks ran. Other straight lines marked the roads.

From his seat Pat could look into the pilot's cabin. He recognized the altimeter that was recording their height. They were a thousand feet above the ground. The air speed meter told him they were flying along at a hundred miles an hour. But he was conscious of no speed. He did not even realize it from the way in which the ground changed below. Nor did he realize that they were climbing, although the altimeter moved steadily toward the two-thousand foot mark.

Soon he caught sight of a broad expanse of water rippling in the sunshine. It was the Detroit River. It stretched below, coming out of the misty east and disappearing in the wide waters of Lake Erie on the southwest.

Pat called across, "There's the river."

His friend nodded. "Look," he directed

Pat stared and saw far below a speck that he soon decided was a launch. It darted from shore toward a larger speck, a plane like the one he was in, lying on the surface of the stream on pontoons.

As they slowly circled he saw the launch reach the side of the plane, and in a few moments the latter, as might a bird, turned in the water. The launch returned to shore while the pontooned plane skimmed across the

surface. Suddenly it seemed to spread its wings and to rise in a graceful curve. It mounted up and up and swung toward the city skyline.

After it had become a streak of light in the distance Pat focused his attention once more on the scene beneath. Now they were over the city itself. Tall skyscrapers seemed tiny and far below. He saw factories belching forth their smoke and long street arteries leading away from the downtown section like the ribs of a fan. But at no time was he conscious of speed or motion except when the plane struck an air pocket and dipped slightly, and then rose again.

Suddenly he recalled Mr. Mayo's request to hold his fist out of the window and feel the wind. He pushed the sliding glass pane to one side and thrust his hand out. The wind felt much as the water did when he dragged his hand behind a rowboat. He was surprised to feel the strength and body of the wind.

Then, as Mr. Mayo had suggested, he opened his hand slowly. The force of the air pushed it back violently against the window sill. The blow jarred him.

"Ouch!" exclaimed Pat. Then he grinned. He had learned something about the air that he had not known before.

He closed the window and gazed down again. The ground came nearer. The trees grew larger. He could distinguish automobiles and even people. He wondered if anything had gone wrong, for he could not see any landing place below.

Then he looked ahead and in the distance recognized the hangar. They were back at the airport again. Smoothly they had glided down and seemed to be riding just above the surface of the ground. The wheels skimmed it once, then touched it without a jar and rolled swiftly toward the rapidly approaching building. In another moment they were slowing up. The plane halted as easily as an automobile.

"Well, Pat, how did you like it?"

The boy glanced up hurriedly and saw Mr. Mayo beside him in the aisle. The aviation chief was smiling quizzically.

"How did you like it?" he repeated.

"Gee, I never thought flying was like that," Pat exclaimed. "I thought it bumped you a lot. I thought it made you scared, but I hardly knew we were moving."

"Well, now you see how easy it is. It's just as natural as driving your car around town, once you know how. Tell me, did you try the experiment with your hand, as I suggested?"

Pat nodded.

"The wind pushed my hand back so hard it cracked my funny bone," he grinned.

Mr. Mayo grinned back.

"That's the reason an airplane can fly," he said. "It's because the air has body. You can feel it. The engines pull the plane forward, and the air lifts it. But you knew all that long ago."

"Yes," answered the boy, "I've read all I could find about airplanes."

"Some day you'll be able to sit up with a pilot and find out *how* it flies. You'll like that, won't you?"

"I'll say I will," murmured the boy. "Although the ride we just had was wonderful. Now I know how it feels to fly."

"Yes. And remember it's an experience no boy before our time has ever had."

CHAPTER FOUR

DOWNHILL ON THE AIR

"HELLO, do you see what I do?"

Both Mr. McDonald and Pat glanced up hurriedly at Mr. Mayo's exclamation. They followed his gaze and in turn gave little "halloa's" of surprise.

"What a queer-looking airplane," thought Mr. McDonald.

The boy knew better. His first glance told him that here was no airplane, although it had wings, a pilot's seat, and controls.

"Here's a chance for you to go on with your lesson," Mr. Mayo continued. "It really couldn't be better. Some day all our pilots will get their preliminary training on a machine something like this."

The "queer-looking" flying machine was small and unusually light. It was in process of assembly at the hands of two young men from the state university. One of them recognized Mr. Mayo and smiled broadly.

"Good-day, Mr. President," he greeted.

Suddenly Mr. McDonald spoke up.

"Oh, I forgot you were the president of the National Gliders' Association. Now I understand why you are interested."

"I was interested in gliding long before I was made president," answered Mr. Mayo. "Gliding is an old art or sport. It's much older than flying."

Meanwhile Pat had taken a stand beside the students and was deeply engrossed in their activity.

"Let him watch them for a while," suggested Mr. Mayo. "No one could give him a better start."

A fast army plane zoomed overhead. He looked up at it reflectively.

"Our modern power plants," he said slowly, "don't fail us very often, but when they do, an airplane becomes a glider. And every flight in an airplane, when it terminates, becomes a glide. The plane simply slides down the air to the ground. That's why I say gliding is the first step on the road of learning how to fly."

The two men chatted in the shelter of the hangar while Pat hovered about the birdlike craft.

"Flying owes a big debt to gliding," Mr. Mayo pursued his theme. "If it hadn't been for Chanute and his gliding flights over the Indiana sand dunes near Lake Michigan, we might never have heard of the Wright brothers."

"That's the way with many things," replied Mr. McDonald. "Someone usually breaks the trail first."

"Well, Chanute was the advance man of the Wrights. They heard of his gliders and started themselves to build one. That's how they became interested. They used to write him from their bicycle shop down in Ohio, and he used to reply, giving them all the ideas he had."

Captain Frank M. Hawks is pilot of the glider being towed by an airplane. This flight was made from Pontiac to Cleveland

GLIDERS

ABOVE: Glider in flight. Note the launching crew in action at the left of the picture.

LEFT: Pat, seated in a glider, is told to take hold of the stick

"Was he a student? I must admit I never heard of him before."

"Chanute was an engineer and a thinker. He developed the idea of using more than one surface—the biplane idea. One of his gliders had actually five surfaces, or wings. His final choice was the biplane."

"So the glider came before the flyer, eh?"

"Even the Wrights experimented with gliders before they tried airplanes."

"Yes, I've heard that."

Mr. McDonald was silent for a moment, watching Pat.

"I didn't realize we owe so much of our present knowledge to those early gliders," he said finally.

"Much more than most of us realize, perhaps. They taught us the use of the tail; the vertical rudder for direction; and the horizontal rudder, or elevators, for height."

By that time the assembly of the glider had been completed. They ended their conversation so that they could see what was going on. One of the students walked over to a young man dressed in pilot's uniform. Pat's eyes were bright with excitement as he came over beside Mr. Mayo.

"The machine is going to make a flight soon," he announced eagerly. "May we stay and watch?"

"Yes, indeed. Why don't you try out the controls?"

Pat hesitated only a second and then darted back to the glider.

"Sit down in the pilot's seat," urged Mr. Mayo. "That's the best way to learn a thing. Do it yourself."

Nobody seemed to object, so Pat sat down in the pilot's seat.

"Now take hold of the stick."

He grasped the control lever firmly. He felt tremendously thrilled, almost as much as if he were going to soar off into the air. The men walked over beside the machine.

"How long those wings are!" exclaimed Mr. McDonald. "Isn't it rather heavy?"

Mr. Mayo smiled.

"You might say that a bird is heavy, too. Yet some birds can glide for miles and miles. The albatross is supposed to have the best gliding angle, about five hundred. That means it can glide five hundred miles while descending one mile. If it could ascend high enough above New York City it could glide to London without much difficulty."

"I don't think anything is prettier than a bird gliding in the air."

"Chanute studied birds, as did many other early pioneers. Any boy can learn a lot about flying by watching the birds around his own home. Bill Stout says the air is filled with hundreds of worm-drive airplanes all the time."

"Worm-drive?" repeated Mr. McDonald, puzzled. Then he laughed as he saw the point.

"Yes. Tell Pat not to overlook them."

They turned to watch the boy again. He was trying out the foot controls, moving the rudder as he pushed first his left foot, then his right.

"Did you find out all about the stick?" asked Mr. Mayo.

"Yes, sir. When you push it forward, it makes the elevators bend down. When you pull it toward you, it lifts them. Just like an airplane."

"What happens when you move it sideways?"

"It lifts the aileron on one wing, and drops one on the other wing."

"Great Scott!" exclaimed Mr. McDonald. "Pat knows more about airplanes right now than I do."

"Most boys do know more about them than their dads. It isn't surprising."

"I wish you'd tell me how a pilot can fly one of these machines without an engine."

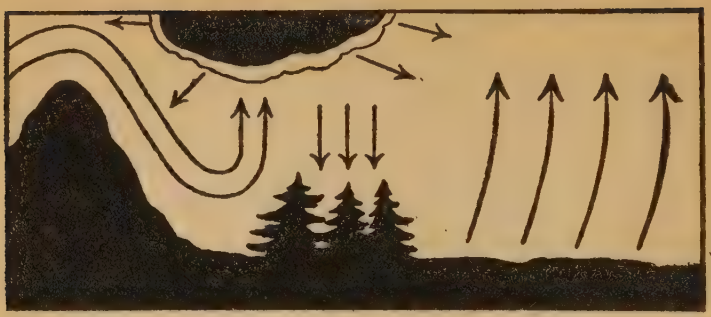
"He uses the pressure of the air—that's what keeps up the glider. He rides on the currents."

"But how does he find the currents?"

"Like a sailboat does. But you mustn't confuse gliding with soaring. The two are much different. Gliding is more like sliding downhill on the air, much as you would coast down a hill on a sled or pair of skis. Soaring is much more difficult."

"In what way?" As Mr. McDonald had said, he was learning, along with Pat.

"Well, perhaps I might explain it this way. The object of soaring is not merely to glide down to the ground,



Mr. Mayo made a rough diagram

but to glide about on a level plane, and even to rise to a higher altitude."

"Do you mean without any power? Any engines?"

"Yes. The pilot looks for upward air currents. They are to be found wherever the currents strike a dense wood, a hill, or some similar obstacle. That," Mr. Mayo added, "is why sand dunes make such an ideal place for soaring. That's why Chanute chose the sand dunes of Lake Michigan for his early experiments."

"What does a pilot do when he strikes an air pocket?"

Mr. Mayo took out a pencil and sheet of paper and sketched a rough diagram.

"Frankly, there's no such thing as an air pocket, any more than there are holes in water. Stick your finger in a glass of water and then take it out. There is no hole. Neither can there be holes in the air. When the air passes over a hill or building, it must rise on one

side and descend on the other. That's what causes the 'bump.' It's really an air wave, just like an ocean wave."

"Do you mean to tell me that pilots can rise to any appreciable height without a motor?"

"Why not? The air is like the ocean, never still. It has its whirlpools and eddies. Some pilots have gone up more than a mile in the air. They have soared as far as ninety-three miles and have remained aloft more than fourteen hours."

By that time Pat's friend was so interested that he wanted to wait with Pat and watch the launching of this strange sort of flying machine. Mr. Mayo assented readily but excused himself, as he had business to transact before leaving the city.

"I'm really sorry I can't stay longer with you," he apologized. "All this has as great a fascination for me as it has for you. But let me give you a suggestion. After you get through here, if you still have time, why not let the boy meet Mr. Stout?"

The idea appealed to Mr. McDonald.

"I will. But I thought he was out of town."

"No. He returned Wednesday. I saw him this morning. But he's very busy, and you'd better telephone him first to make sure he's in."

"Yes. I'll do that."

Mr. Mayo reached into a pocket and brought out a small white ticket.

"I had the office girl make out this pass for you and

Pat," he said. "Now, I'll leave you here. Good-bye, Pat."

The boy rushed over in haste to shake hands with the aviation executive and thank him for his great kindness. After the sedan rolled away the two rejoined the student by the glider. He had consented to act as their teacher. His name proved to be "Johnson"—at least, that was what the others called him.

The glider was being towed along the runway toward a slight knoll on the far side of the flying field.

"While we're waiting for it to take off, I'll tell you about it," said Johnson. "If you watch closely you'll see two groups of men, each holding one end of a rubber rope. They will walk away from the glider to stretch the elastic while a third group will hold the machine steady. When this last group lets go, the elastic will jerk the glider into the air like a stone from a sling shot."

They approached near enough so that Pat could see the pilot had been strapped in his seat.

"So he won't fall out or be thrown out," Johnson told them.

The rubber shock cord was attached to the machine by a ring that had been placed over an open hook.

"When the glider goes into the air the ring will drop off," he explained.

The voice of the coach sounded above the general confusion.

"It's time to make the first flight, men. Get your positions."

Five men lined up at either end of the rubber rope, while another group, as Johnson had explained, took hold of the tail structure.

"Ready—walk."

The two rope crews walked ahead slowly about ten steps. The rubber rope, Pat could see, was stretched in a sort of V-shape having its apex at the ring that held the hook.

"Run!" called the coach.

The crews broke into a trot and ran ten more steps. The men holding the glider were pulling hard.

"Turn loose!"

At the shout, they released their hold. The glider sailed forward and up, rising as it pushed against the air currents.

"Gee, just like a bird," cried Pat.

The sight of the pilot riding the air in this light craft held both Pat and his friend spellbound. He seemed to be doing it without the least difficulty.

"He's an experienced pilot," Johnson went on. "We never let a beginner start when the wind is blowing more than fifteen miles an hour."

"But is it safe?" Mr. McDonald inquired.

The university man chuckled.

"You fellows should get over the old-fashioned idea that the air is unsafe," he remarked gently. "Forget you are in the air and imagine you are in an element like water. A bird never stops to think whether he is safe—that is, if a bird can think at all."

Mr. McDonald finally decided it was time to leave. After the glider had alighted on the ground he broke the news to Pat.

"I'd like to stay here all day," he confessed. "But I've arranged for another lesson. I'll get someone to drive us back to where my car is parked, and then I'm going to call up another man. If he's in we'll go and see him. He's an old friend of mine, like Mr. Mayo."

"That's fine," said Pat. "You've given me a real start already—my talk with Mr. Mayo, my first ride in an airplane, and now this experiment in gliding."

"The last item was entirely accidental," said Mr. McDonald. "Luckily, Mr. Mayo noticed the glider when we got back from our flight."

"Who is this friend you spoke of?"

"Mr. Stout. W. B. Stout."

"Gee, would he talk to me?"

"Why not? Mr. Stout is interested in boys like you."

"That's so. He's president of the Boys' Model League."

"Then it's all settled. By the way, here's a pass Mr. Mayo left for us. You'd better take it and put it in a safe pocket. And now, let's look for a ride."

Mr. Mayo and Pat

Pat meets Mr. Stout

The ground seemed like a checkerboard

"They're more like grandfather and grandson."

CHAPTER FIVE

A VISIT WITH MR. STOUT

THEY found Mr. Stout in his laboratory on the other side of Dearborn. As soon as they arrived they were ushered into the presence of this man whose name is known from one end of the country to the other as an airplane designer.

"Come over here and sit down beside me," he invited, after introductions had been made. "I'm always glad to talk to a boy. Before I started to design airplanes I wrote for boys myself."

Pat liked his eyes. They gleamed from behind dark-rimmed spectacles—the eyes of an enthusiast. He recalled a story he had once heard of how this man, when beginning his airplane activities, had used the basement of his house for an office and acted as his own stenographer.

"How old are you, Pat?" Mr. Stout began.

"Thirteen, sir. I'll be fourteen in December."

"Um-m-m. And so you want to learn how to fly, do you?"

"Yes, Mr. Stout."

"To be sure. One of these days you'll see boys learning to fly just as they learn now to drive their dad's cars."

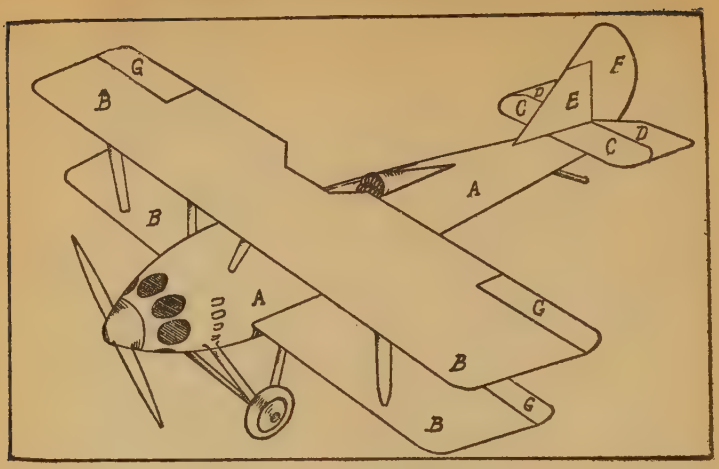


DIAGRAM OF BIPLANE

A—Fuselage *D—Elevators*
B—Wings *E—Fin*
C—Stabilizer *F—Vertical Rudder*
G—Ailerons

"That's what I think, too," said Pat. He was feeling tremendously at his ease.

"But thirteen is—well, it's a bit young. Even fourteen is."

"I don't expect to fly a plane for a while yet," the boy hastened to explain. "I'd like to learn something about it first."

"Sure you do. All boys do. It's only natural. What do you want me to tell you about? Airplane design?"

"If you please, Mr. Stout."

"Where'll we start, then? My friend Mac here said over the phone that you wanted to begin at the bottom."

"I know some things, of course. I've made my first flight already. I know," he added with a smile, "that air is what keeps the planes up."

"You mean wind. An airplane in its simplest form is a machine that makes its own cyclone and then rides on it like a witch on a broom. Let me show you a few things about the action that air has on a plane surface."

He reached across his desk and picked up a sheet of cardboard about the size of an ordinary letter.

"You drove here in a car, I suppose?" he asked, turning to Mr. McDonald.

"Yes, Bill."

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"Well, when you leave here, ask Pat to hold this card out of the window as you drive along. Do it first when you are going at fifteen miles an hour; and again when you are going thirty. Let him hold it at an angle of about fifteen degrees, like this."

He illustrated his meaning by tilting the card so that it formed an angle as described. He called it "making your own wind tunnel." Then he handed it to Pat, who retained it carefully during the remainder of their talk.

"I like to think of the air as an ocean," Mr. Stout resumed, "in which you and I and all other human beings walk about just as marine animals might walk along the bottom of the sea. As we mount up toward the surface of this air ocean, the pressure decreases just as it does with water. Besides having pressure, air resembles water in that it has volume and substance. Every boy understands this."

He paused for a moment and, when Pat nodded his agreement, continued:

"Your bicycle pump will quickly show you that air has substance. You can feel it pushing back against the plunger. Like water, air will support anything lighter than it is. But our problem here is to navigate the ocean of air with something that is heavier than it is. We have the same problem that you have when you go in swimming. Your body is heavier than the water, but you support yourself by the motions of your arms and legs."

Again he paused to refer to a simple example.

"Did you every skip or sail a stone across the surface of water? Well, there you had a somewhat similar situation. The stone was heavier than the water and would sink at once if you didn't keep it moving."

Pat had no trouble in following the noted designer. He was intensely interested.

"There is no such thing as empty space in the world as we know it," Mr. Stout went on. "This room is filled with air, even if we don't see it. I think you and I are agreed that we have this element about us and could fly in it if we only had wings. But unfortunately, we don't have them. The next best thing we can do is to make a boat that will take the place of wings for us. In other words, we must design the airplane."

He reached across his desk again and picked up a sheet of letter paper.

"Let this represent a plane surface. You have seen

the wind blowing things about so that you know it has enough force, or velocity, to carry along things many times heavier than it is. It can slam heavy doors. It can move great sailing vessels. It can turn windmills. It can pick up leaves, paper, doors and even buildings and carry them many miles. But of all objects, the plane surface rides the wind most easily. Do you know why that is?"

Pat cleared his throat and ventured an answer.

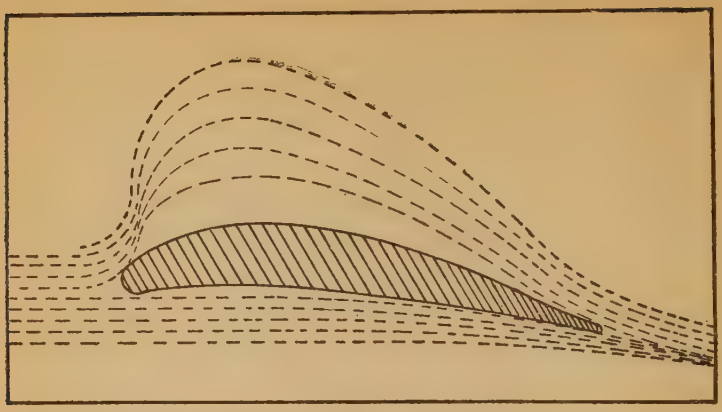
"Because the wind has more room to push against. And it doesn't weigh as much."

Mr. Stout smiled.

"Something like a kite," he suggested. "Now, I'm going to let you into an interesting secret that we have discovered about the air and plane surfaces. I want you to watch this sheet of paper while I perform a simple experiment with it."

With those words he lifted the sheet to the level of his lips, holding it on either side by thumb and forefinger about two inches away from his mouth. With the thumb and forefinger, he curved the edge nearest his lips, permitting the rest of the sheet to drop over his hands and hang down. Then, while Pat and his friend, Mr. McDonald watched closely, he blew across the surface of the sheet, first above it and then below.

The watchers were surprised to see how the far end of the sheet lifted when Mr. Stout blew *above* it. It seemed to rise more quickly and higher than when he blew below. He laughed amusedly.



It showed how the currents struck the leading edge and rose above the cambered surface

"The explanation is really very simple," said he. "When I blew *above* the sheet, I pushed away the air that was resting there. What happened then? The air, pressing up from below, was able to exert itself and lift up the sheet. You might say that when I blew above it, I made a partial vacuum, or, as we call it, a 'negative pressure.'"

He called their attention to the manner in which he had curved the front edge of the sheet nearest his lips.

"Perhaps you didn't notice it," he said, "but when I blew, I did so directly against this curved edge. Perhaps you've seen that the front or leading edge of an airplane's wings is always rounded, and that the upper surface is always curved. In airplane work we call the

curve of the upper surface the 'camber.' The degree of vacuum you can obtain above the camber is what determines the lift you can get out of your airplane."

Pat repeated the same experiment, blowing against the curved edge, while Mr. Stout rapidly sketched a diagram on a fresh sheet of paper. It showed the wing of an airplane going through the air and showed how the currents struck the leading edge and rose above the cambered surface.

"That's why the top of a wing is so important," said he. "Its camber is quite a study all by itself."

"I understand how the pressure of air beneath a wing can support it," said Pat, "but why is the camber important?"

"That's a sensible question," replied Mr. Stout. "The wings of the first flying devices, you know, were not cambered. Since then man has learned about air currents. They flow along with considerable force, just as currents do in water. The wing of an airplane has to ride in the air as a boat does in water. Besides presenting a wide surface for the air to press against, it is cambered to allow for these currents."

"Just like a boat," Pat interjected.

"Correct. The side of a boat is curved, isn't it? Or, as we say, stream lined. The curve enables the boat to move through water with the least possible disturbance, and still carry a load."

"But why isn't the lower side of the wing curved, also?"

"Because that side serves a different purpose. Air currents go around curves faster than they go along a straight line. You've noticed, perhaps, in little streams how fast the water swirls around curves."

"Yes."

"And how fast the wind goes around a corner when it is blowing real hard?"

"Oh, yes."

"Now, then, if the currents go faster above the wing than below, they help the air below to hold up the wing. The air is said to be in a state of suction, just as it is when you blow above the sheet of paper. The air pulls above the wing, because it is *curved*, just as I showed you in that diagram. It pushes below, where the wing is flat and can take advantage of all the pressure."

"Then the wing with the biggest curve will lift the most?"

"Well, that depends. Thick wings serve one purpose, thin ones another. It all depends on the design of the plane."

A young woman opened the door softly and stepped in.

"Excuse me, Mr. Stout," she said, as he looked up, "but the gentlemen from Cleveland are waiting for you at the airport."

He rose, a bit regretfully.

"I'll have to ask you to excuse me, Pat," he begged. "I've got to run over to the airport to meet some gentlemen. But before we go I'll tell you something about the

camber of a wing that you'll always remember. Did you ever hear how its value was discovered?"

Both shook their heads.

"They tell a story about the famous German glider, Otto Lilienthal, who came ten years before the Wright brothers. He termed the superior value of curved lifting surfaces over the flat plane surfaces 'the real secret of flying.' The story goes that he discovered it when he happened to notice the curved sheets on wash day, blown by a strong wind as they hung on the clothesline, flapping far above the horizontal."

"I've seen that myself," Pat exclaimed.

"Yes, all of us have. But few persons have considered its significance. At that time, all the learned scientific men believed that the flatter the wings, the greater the speed that could be attained. And even while Lilienthal was experimenting, a commission appointed by the state declared officially that man would never be able to fly."

As he reached for his hat and coat Mr. McDonald asked: "Could we drive you to the airport? Then you can watch Pat try the experiment with the sheet of cardboard."

Mr. Stout agreed readily with the suggestion. On their way Pat sat in the back seat with him and held out the sheet of cardboard while Mr. McDonald kept down the speed of his car to fifteen miles an hour. Pat found that he could feel the force of the air or wind against its surface whenever he held it at an angle.

When the speed was increased to thirty miles an hour, it was all he could do to keep the card in position.

"If you were going fifty miles an hour," Mr. Stout told him after he had finished, "you couldn't hold the card at all. The wind would tear it out of your hand."

CHAPTER SIX

THE THIRD RUDDER

AT THE airport they found four men awaiting Mr. Stout's arrival. Not far from where these men stood was the trimotored plane that had flown them from Cleveland and was now parked on the field near the hangar. Their attention had been attracted by another plane in the hangar, a peculiar model of apparently antique vintage. They were gathered about it, studying its flimsy construction, when the car bearing Mr. Stout, Mr. McDonald, and Pat rolled up.

After greetings had been exchanged, one of the newcomers asked Mr. Stout about the plane.

"Nobody ever flies in such a dangerous contraption, do they?"

Mr. Stout laughed.

"Not to-day," he replied. "But that plane has an interesting history. In one just like it Louis Bleriot flew across the English Channel."

"Great Cæsar!" exclaimed the visitor. "Well, he had a lot more courage than I have. And I'm not ashamed to admit it."

"Why, it's hardly bigger than a mosquito!" declared another.

"Look at it alongside that big trimotor transport," suggested a third. "They look like father and son, the big fellow and the little one."

"They're more like grandfather and grandson," rejoined Mr. Stout. "The little fellow is the grandfather. What better illustration could you find of the strides that aviation has made during the past twenty or twenty-one years?"

"Ain't it the truth?" remarked the first questioner. "Tell me, who was this man Bleriot? I mean, what else did he do?"

Mr. Stout's eyes noted Pat's eager expression. Something told him that this boy could explain more about the famous Frenchman than any one of the grown-ups. He put a hand on Pat's shoulder and led him forward.

"Let's see what this boy can tell us about him," he said. "I've just spent half an hour with him to get him started on the flying path."

"Go on, son," encouraged one of the Cleveland men, who had not spoken thus far. "I'll bet you know all about Bleriot—and the rest of the aviators, too."

Pat found himself surrounded by a little circle of smiling men, each of whom seemed much interested in this business of flying. The position might have confused him if he hadn't known what he was going to talk about. Yes, he knew all about Bleriot. Bleriot was one of his heroes. He had read of him in more than one book.

"Bleriot is still living," he began slowly. "He is a brave Frenchman. He won five thousand dollars by

flying across the English Channel on July 25, 1909. The money was offered by the London *Daily Mail.*"

"What else did he do besides cross the Channel?" someone asked. "We all know he did that. Tell us something else about him. Was he a flyer?"

"Well, he smashed up a lot of planes," said Pat. "One book said he broke up twenty of them before he flew a yard."

"What was the matter with him? Couldn't he fly?"

"You've got to allow for the fact that he had to teach himself. They didn't have flying schools in those days."

"That's right, Pat," Mr. Stout added. "It was men like Louis Bleriot, smashing up plane after plane, who found out much of what we know to-day about flying. If it hadn't been for them we wouldn't be flying to-day. Look at the Wright brothers, for example. Eh, major?"

The man he addressed as "Major" proved to be the fourth member of the Cleveland party, Major Jack Berry, manager of the municipal airport in that city.

"Yes," he returned quietly. "And if you'll look closely at this Bleriot plane, you'll see a trace of the Wright brothers."

The other three men from his home city glanced at it curiously, while Mr. Stout grinned.

"I'll bet Pat noticed it long ago," he asserted. "Didn't you, Pat?"

The lad had been scanning the tiny plane during the chat. It was unlike any airplane he had ever seen. He noted the Gnome rotary motor, built so that the cylin-

ders revolved with the propeller; the pilot's seat in the fuselage close to the trailing edge of the wings; the open framework of wood behind the seat; the gas tank in front of the seat, between it and the motor; the rudder, elevators, and stabilizer. He saw that it had no fin. As his gaze centered on the wings, a smile crept over his face.

"There it is," he exclaimed. "Just look at the wings!"

"Why?" asked one of the visitors. "Do you mean because it hasn't any ailerons?"

"Yes, sir. Bleriot controlled his side balancing by warping his wings."

"And what has that got to do with the Wright brothers?"

"That was their big discovery, sir. They found out how to stop an airplane from seesawing in the air. The books call it 'lateral balancing.'"

"Pat is right," said Mr. Stout. "We wouldn't think of warping our wings, to-day, yet that is exactly what the Wrights did. And that is what Bleriot did with his plane when he flew over the Channel. If you examine these wings, you will see that the rear edges and the outer tips are flexible, and are controlled by wires which the pilot operated by means of push sticks."

"Instead of flipping a hinged aileron up and down, he flopped the rear edges of the wings," suggested the major.

"By the way," said Mr. Stout, turning to Pat, "what does the word 'aileron' mean?"

"It's a French word," said the boy. "It means 'little wings.'"

"Yes. The Frenchmen regarded them as little wings, attached to the big ones. The French developed the ailerons, you know, partly because the Wright brothers had patented the warping idea."

"I didn't know the Wright brothers discovered that," somebody said.

"They practically gave us a third rudder," said Major Berry.

"Exactly. Before them, men could control the direction of flight by means of the vertical rudder; and they could control altitude by means of the horizontal one, which we know to-day as the elevators and stabilizer. But they couldn't prevent the wings from seesawing up and down—getting off balance. The Wright brothers worked on this until they discovered that it could be prevented by moving the rear edges of the wings."

"What was the date of their first successful flight?"

"Tell them, Pat," Mr. Stout directed.

"December 17, 1903. It was at Kitty Hawk, North Carolina. The first one lasted only a few seconds, but Wilbur Wright made four flights that same day."

"How did the first Wright plane compare with this one of Bleriot's?"

"Perhaps I had better compare the one that Orville Wright flew at Fort Myer in 1908," said Mr. Stout. "That was the first public flight in this country. He sat on the lower wing, for it was a biplane. He was exposed,

of course, to the weather. The motor was behind the pilot's seat. It drove twin propellers. The elevators were in front of the pilot."

The men smiled at this word picture of the famous pioneer plane.

"It was just as much of an improvement over the earlier flying machine," he went on, "as the modern transport is over the Bleriot. When Santos-Dumont made his flights in 1906, the tail actually stretched out in front of him. When he wanted to balance the machine he had to twist around in his seat. Twisting in the seat was the only way pilots had of balancing their planes in those days. That is why the discovery of the third rudder was such an improvement."

It was long past lunch time, and Mr. McDonald felt that he must return to his office. The time had sped so rapidly that neither he nor Pat had realized how late it was. They bade Mr. Stout and the gentlemen from Cleveland "Good-bye," and then Mr. McDonald drove Pat back to his classes.

"I'll call you up again as soon as I get a little time," he promised. "How do you like your experience so far?"

"My first lesson was a dandy," Pat exclaimed. "So was my second. But," he added with a sigh, "I've sure got a lot to learn."

CHAPTER SEVEN

THE SKIN OF AN AIRPLANE

WHEN Pat went back to school his head was whirling. Already he had met two men who were famous in the world of aviation, and both had taken an interest in getting him started toward his ambition. He had even made his first flight, a thing he had not expected to do for a long time.

"They are helping you," remarked his mother, after he got home and told her of his experiences, "because you want to be helped. You know the Good Book says, 'Ask and ye shall receive.'"

Next day was Saturday, with no school. As soon as he had finished his chores, Pat obtained permission to visit the airport and use the pass Mr. Mayo had given him.

"I want to see what the inside of the factory looks like," he announced. "The caddy season is over for this year, you know."

By that time Mrs. Callahan had decided that her son could be trusted to take care of himself, and she was secretly proud of the previous day's accomplishments. Unlike some mothers, she had no fears for his safety in

the air. Every day she saw the big transport planes crossing the sky and knew there was no more danger for him in the air than on the ground—perhaps less.

The only condition she insisted upon was that he return home early. He rode downtown on the bus and walked from the drug store past the building where he had met Mr. Mayo, half a mile or so to the long white stone and brick structure which housed the airplane factory. It was guarded from unwelcome visitors by a tall fence of meshed wire. He dug his pass from his pocket and gave it to a watchman who waited beside a gate.

"Admit Patrick Callahan," read the sentinel aloud. He scanned the boy good-naturedly. "Lookin' for a job, lad?"

"Not yet," grinned Pat. "But I will be, some day."

The guard grinned back.

"Go on in," he said, "but keep out of the way of the planes."

Pat felt a secret thrill of anticipation as he entered the enclosure and turned his steps toward the nearest door. From inside the plant came the sound of men at work, bustling activity. Above all else came the steady rat-a-tat-tat of the rivet hammers. The chorus burst upon his ears with a tremendous clamor when he opened the door. He stepped inside.

As he stood uncertainly, staring about him with wide-open eyes, a guide approached. He saw the boy looking around and went forward to his assistance.

"Who are you looking for, boy?"

"I don't know, sir. I'd like—I'd like to find out how an airplane is made."

"Well, maybe I can help you. What's it for? High-school essay or something?"

"No, sir. It's for myself. I'm learning how to fly and thought I ought to know something about an airplane."

"So that's the idea, eh? Then you want more than the ordinary visitor, I guess. I'll see what I can do for you. Come along."

Pat hustled after him as he started down the aisle.

"I'll put you in touch with one of the workmen," he said. "That's the best way for you to find out everything. After he gets through with you in his department, let him take you on to the next."

"Maybe I could follow an airplane right through the plant?" suggested the boy.

"You can if you stay long enough. Usually we don't work here on Saturdays, but to-day we happen to have a rush order to get out."

They stopped beside a tall rack, in which thin sheets of metal stood on edge. A young man, not much taller than Pat but eight or ten years older, came up and lifted out one of the sheets, inspecting it carefully.

"Here, Shorty," said the guide with a smile, "here's a customer for you. Tell him about dural and alclad and then take him on to the next department."

"That's quite an assignment, Bub," said Shorty, smiling. "Where shall we start?"

"Isn't that what you make the planes of?" asked Pat curiously, motioning to the sheet. "You seem to lift it like it was made of paper."

"Try it for yourself," suggested his willing tutor.

Pat sized up the big sheet for a moment, then took a firm hold and tugged at it with all his strength. To his great surprise, it moved at his slightest touch, and the entire sheet seemed nearly as light as he had described.

"Gee, who would have guessed it!" he exclaimed. "Of course," he added, "it has to be light if you use it in airplanes."

"Yes. And also strong. That metal, Bub, has a tensile strength of fifty-five thousand pounds to the square inch. Before we heat-treat it, it is not nearly so strong. It is called 'du-ral-u-min' because it is an alloy of aluminum. It has the tensile strength of mild steel and weighs only one third as much."

"Those sheets look rather thin to me," said Pat.

"Well, they are. Some are only twelve one thousandths of an inch thick; and others are ten one thousandths. That's a hundredth part of an inch, you know."

"Then a deep scratch would almost cut one in two."

"Oh, we don't take any chances with scratches. We inspect each sheet separately, and when we find one that is scratched, out it goes."

"What do you mean when you say you heat-treat it?"

Shorty replaced the sheet of duralumin in the rack.

"Heat-treating is a big subject, Bub. Perhaps I can explain it this way. We place the metal in a solution of chemical salts and heat it to a temperature of about nine hundred and fifty degrees. Believe me, that's *hot.* Then we quench it and we find that the dural—that's short for duralumin—has acquired a much greater tensile strength than it had before we gave it the treatment."

"You increase its strength?"

"You bet. Another thing. After the dural has cooled, it begins to harden. We've found that it is much easier to work with; in fact, we *have* to shape it up into the different parts before it gets too hard. That means we must begin working with it within a few hours after it has been quenched and cooled."

"What parts do you make of it?"

"Most of the airplane. Dural is used a lot in airplane manufacture these days. Of course, the motor mounts and braces are made of chrome molybdenum steel, the very stoutest and toughest we can find. The covering, or, as we call it, the 'skin,' is made of another form of dural known as 'alclad.' Have you ever heard of that before?"

Pat shook his head.

"It's really quite simple. It means 'clad with aluminum,' or aluminum-clad. It's a form of dural devised for covering exposed surfaces. Dural has a tendency to corrode when exposed to certain weather conditions, as

salt water. It has no such tendency under cover. Alclad is dural covered on both surfaces with pure aluminum. A cross section of it resembles a sandwich."

"So that the outside which is exposed to the weather is pure aluminum?" asked Pat, beginning to understand.

"Yes. Aluminum, you know, doesn't corrode easily."

"That's a grand idea," Pat agreed. "But why do you make all those waves or ripples in the skin of the airplane? Why don't you put the sheets on just as they are here—flat?"

"Well, Bub, I'll let you answer your own question. Here's a plain piece of metal."

He handed Pat a small piece of alclad.

"Bend it." Pat did so.

"Now, here's a sheet of metal that has been corrugated. Try bending it across the corrugations, counterwise."

Pat tried it and found that it was much more difficult.

"I see now," he said. "That's another grand idea. I'm learning that there's a good reason for many things I never suspected."

"Sure. Now," said Shorty, "I'll show you one of the presses where we shape the dural into the frame members."

He led the boy toward a powerful machine that stood beside several others just like it in a section by themselves. Between its jaws was a platform on which a sheet of dural was being placed. The operator released

the upper jaw, and it pressed down with tremendous strength, pushing the metal into a die held by the lower jaw and thus forcing it into the desired shape.

"Here's another press that may interest you," he went on.

It proved to be the one on which the alclad sheets were corrugated. It was so wide it could handle a sheet fourteen feet long and sixteen inches wide at one time.

"You're about ready for the jigs now," said his teacher. "That's the department where we put together the skeleton of the airplane."

As they walked toward the place Shorty indicated Pat spied on a table an oval-shaped object, about twice as big as a steel barrel and made of shining metal. Its two ends had not yet been covered, so it was possible to look through it from one end to the other as through a tunnel.

"What's that thing?" he asked. "Part of an airplane?"

"What? Oh, that's a gasoline tank. It's being assembled right now by the workmen. Do you want to see how it's done?"

Pat did, so the two halted beside the table. Although the object seemed large and bulky, Pat tried to lift it. He was surprised to see how easily he could move it about.

"Look inside," invited Shorty.

Pat peered into the tank through one of the ends and saw several layers of metal, each perforated by holes.

They looked something like false bottoms and appeared to divide the tank into compartments.

"Those are baffle plates," his guide explained. "The holes permit the fuel to flow back and forth so that it won't be confined in a single compartment. The purpose of the plates is to restrain it from rushing from one side of the tank to the other, whenever the airplane happens to be taxiing over rough ground or engages in violent maneuvers."

"Another grand idea," commented the boy.

Pat lingered a moment longer to find out how the tank was formed. He saw that a single sheet of metal, which Shorty told him was aluminum, was bent around until the two edges met. They were welded together. The baffle plates were welded to the inside surface of the tank. Then a cover, one for each end, was welded in place, and the tank was ready for use.

After he had watched one made Pat walked on with his guide and found himself suddenly in the midst of a busy scene. Workmen seemed to be engaged in building toy houses out of metal rafters and beams.

"This is the place," said Shorty. "This will interest you much more than my department. Hey, Chris. Come here a second."

Pat turned and saw a new workman, who greeted him pleasantly.

"Wait till I rub this grease off my hands," Chris apologized, as he wiped them against the side of his overalls. "Now, lad, I'm at your service."

Pat thanked Shorty for his kindness.

"That's all right, Bub. Don't let Chris do any jigging, even if this is the jig department."

Both Pat and Chris grinned at his sally, and Shorty went back to his sheets of dural and alclad.

CHAPTER EIGHT

JIGS AND RIVETS

"JIGS?" repeated Pat. "What's a jig?"

Chris scratched his head and studied the floor for a moment.

"I've asked lots of men that same question," he confessed, "and I've never got an answer yet. It's kind of hard to explain. Let's look at one. That'll tell you better'n words."

He led his inquisitor to one of the structures that Pat had previously noticed. It was made up of cross bars and uprights of stout metal. But the strange thing about it was that the workmen seemed to be putting the pieces together inside an outer framework, which told them where each one should go.

"There you have it, lad. That outside shell is what I mean by a jig. It's a sort of guide for us workmen. It's made of steel so we can't budge the guiding edges or push them out of shape."

He motioned toward the section which the men were riveting together, piece by piece, inside the jig.

"Climb up in there and take a look, lad," he suggested. "See if you can guess what the men are making. Look toward the far end."

Pat hoisted himself up through the opening and faced the direction indicated.

"I know," he said suddenly. "That's going to be the pilot's cockpit."

"Correct, first guess. This section—which we call a 'bulkhead'—forms the extreme end of the fuselage. After its members have been assembled and riveted together inside the jig the workmen will lift it out, much as you would take a butter patty out of a mold."

"I see now," Pat exclaimed. "The other sections are assembled in jigs and afterward are added into this one."

"That's right, lad. You're learning. There are thirteen sections in the fuselage. They are assembled together in the next department."

"I suppose the first section is riveted to the one behind it, and that one to the next one, and so on."

"Just like a bridge."

Pat then climbed down from his perch and stood for a time to admire the skill with which the workmen operated their rivet guns. Chris, with a twinkle in his eye, nudged Pat's arm.

"While you're watching them," he said, "see if you can find anything queer about them rivets."

That put Pat on his guard. He studied the little round heads closely. He noticed how bright and round they were, and how evenly they were pressed into place. Suddenly he saw that a tiny projection, somewhat like a

boil, stuck out from most of the rivet heads, yet on others, here and there, no such projection appeared.

"There's one difference," he declared excitedly, as he pointed it out. "It's not much, but it's the only thing I see."

The face of his instructor broke into a broad grin.

"Lad, you've a sharp eye," he complimented. "That's the very difference I meant. The teeny nipple on the rivet head tells us workmen a lot. It tells us that the rivet is made of dural. The plain ones are made of aluminum. That's how we tell 'em apart."

"Gee," murmured the boy, "that's another grand idea."

After that they sauntered through the department, seeing how the various sections of the fuselage were assembled, one by one. At length they turned their steps toward the place where the thirteen sections were brought together into the completed fuselage.

Workmen with rivet guns were busy on either side of the cabin. Pat saw how the "skin" was spread over the framework. He noted that the fuselage rested on a sort of dry dock, or cradle.

"Say," he asked abruptly, "how do they put the skin on the bottom of the cabin?"

"When they're ready they lift the fuselage off that dock and suspend it in the air," replied Chris. "Then the men can get at it underneath."

"It looks like the cabin of a cruiser," Pat remarked.

"So it does. When these sections are all joined to-

gether the fuselage is a single rigid unit able to resist strain from any direction. The skin adds more strength."

"How do you know it's strong? Do you have any way of trying it out?"

"Of testing it? Sure. But I'll have to let someone else who knows more about it explain that part of it to you. Let's see."

He led Pat toward the side of the factory and glanced down a wide aisle.

"I'm looking for one of the bosses," he said. "They can tell you better than I can. Wait! There's Mr. Goin. He's the superintendent. I'll call him."

In another moment Pat was shaking hands with a square-shouldered individual who he discovered was the "big boss" of the entire plant. It was he who directed these hundreds of men in their work. He was very busy at that particular moment, but he halted at the call of Chris and strode over.

"So you're following an airplane through the plant, eh?" he quizzed. "Seeing how we make them and then how to fly them?"

"Yes, sir," said Pat respectfully. "I hope you don't mind answering a question for me."

"Not at all, son. What's the question?"

"I was wondering how you test your planes to find out how strong they are."

"Well, I'll be glad to tell you. First, I should explain that we are checked by the Department of Commerce. There are government inspectors working here all the

time. Men like them are assigned to all the airplane factories."

"I didn't know that."

"The government gets copies of our blueprints and specifications and checks us on the theory of our designs, even before the planes are built."

"So that you won't get started wrong."

"Yes. The department has worked out safety factors to which each ship must conform. They are based on a stress analysis for each part of the ship. Even the tail has its stress analysis. The safety factor on the fuselage is four and one half. That means the strength of the material in the relationship in which we use it is capable of supporting four and one half times any load to which it might be subjected."

"Why do you make each part of the plane so much stronger than the load it has to carry?" Pat asked.

"That's to make sure there is plenty of safety under all conditions. This is checked both by ourselves and by the government. We have what we call sand-loading tests. We load an airplane part with sand until it fails, in order to determine its strength as part of the assembly. After we have done that enough times we know the point of failure of any part. So you might say we check the parts not only theoretically and mathematically, but also by physical tests."

"Then you test the plane by flying it, don't you?"

"Oh, yes. Every plane is test-flown for five hours before it is delivered. The test pilot and chief mechanic

fly on those trips together and wear parachutes. Their job is to find out if there is anything wrong with the plane."

"How do they do that?"

"You should watch them some day. The pilot stalls the ship, makes vertical banks, and performs lots of other exciting maneuvers."

"I'd like to watch him," said the boy. "And I want to thank you for telling me all this."

"That's all right, son."

The superintendent hurried away, and Chris took Pat back across the factory.

"Here's another department," he announced as they neared a section where more workmen were toiling over jigs.

"Do you know what the control surfaces of an airplane are?" he went on.

Pat nodded.

"They're the movable surfaces, aren't they? Those the pilot works from his cockpit, such as the rudder, elevators, stabilizer, and ailerons?"

"Well, here's where they're assembled. Each has its separate jig, you see."

Pat observed that each jig was constructed according to the shape of the part that was to be assembled in it; and that each part was in due time covered with skin, just as the fuselage had been. He saw the men build the long, narrow stabilizer, the vertical rudder, the fin to which the rudder is attached (sometimes called the

"vertical stabilizer"), and the elevators that work off the stabilizer. When he came to the aileron jigs he recalled the conversation about the "third rudder."

"Now," said Chris finally, "it's time for you to move on to the wing assembly. That's a separate department. I'll get someone there to take you in tow. I've had you long enough, don't you think?"

Pat laughingly assured him that he had no desire to change guides, but Chris was anxious to return to his own job. He led the boy to a tall framework which reached up almost to the very roof of the factory.

"The wings are made in three sections," he began, "and here's the jig for the center section. That for the wing tips is over there."

Pat looked and saw another tremendously tall framework on which other workmen were engaged. His guide walked over to one of the men whom he knew. In a few seconds he came back, followed by his friend.

"Here, lad, is where I leave you," he said. "Shake hands with your new teacher, Mr. Roberts. We call him 'Bobs' for short."

"So I'm to show you how the wings are made, eh?" said Mr. Roberts cheerfully. "I know you're going to like this department. It's really very interesting."

"That's fine," exclaimed the boy. "But it'll have to go some to be more interesting than those I've already visited."

"Well, we'll see. Let's go back a few steps and start at the very beginning."

Pat followed him as they walked with Chris back to where the control surfaces were being assembled. There Chris bade them "Good-bye" and hustled away. They turned their attention to the first steps in the making of the airplane's wings.

CHAPTER NINE

WINGS

MR. ROBERTS halted Pat beside a long, rounded pattern of wood, slightly resembling the upturned bottom of a boat. On it a workman was shaping a narrow strip of corrugated alclad. He moved it backward and forward carefully, at the same time checking its curve with his firm hands.

"Here's a job where you have to be an expert," Mr. Roberts explained. "Here's where we form the leading edge of the wings. I suppose you know what that is, don't you?"

"Yes, sir. It's the curved edge. It strikes the wind first."

"These edge panels are called 'nose formers.' They are not as easy to make as you might think. Along the wing tips the edge changes constantly as it gets farther away from the fuselage. At the extreme tips it diminishes into a thin, cutting edge."

"That means that the edge on one side of a panel is longer than the other?"

"It means that the corrugations must be parallel to the line of flight, no matter how much the wing tip tapers."

He pointed to a small machine which a workman was operating. A strip of alclad was being run through it.

"That man is rolling the corrugations," he said. "They have to be rolled just so."

"Then these panels, after they have been rolled and shaped, are set along the leading edge, side by side?" asked Pat, who was beginning to understand the process.

"Yes. When you see the completed wing, look along the leading edge and you'll see them, each one in its place and all together making a perfectly curved edge. Now, let's examine the parts that hold the wing together and give it its strength."

He escorted the boy to a section close by, where numbers of men were toiling over low jigs, each about waist high.

"The skeleton of the wing," he said, "is a whole lot like that of a bird. Only we call the 'bones' by different names. The strongest supports are the spars, of which there are three in each wing section. They support the ship. Between them are auxiliary spars, whose function is to help support the skin. There are five of them in between the main spars."

"What is a wing spar?" asked Pat.

"Let me show you the inside of one of the wings, and then you'll understand."

His guide took him across the floor to a finished wing which had not yet been assembled to a plane. Pat peered into the interior and recognized at once the three main

spars extending through the wing, with the five auxiliaries. After he had examined them to his heart's content Mr. Roberts led him back to the jigs once more.

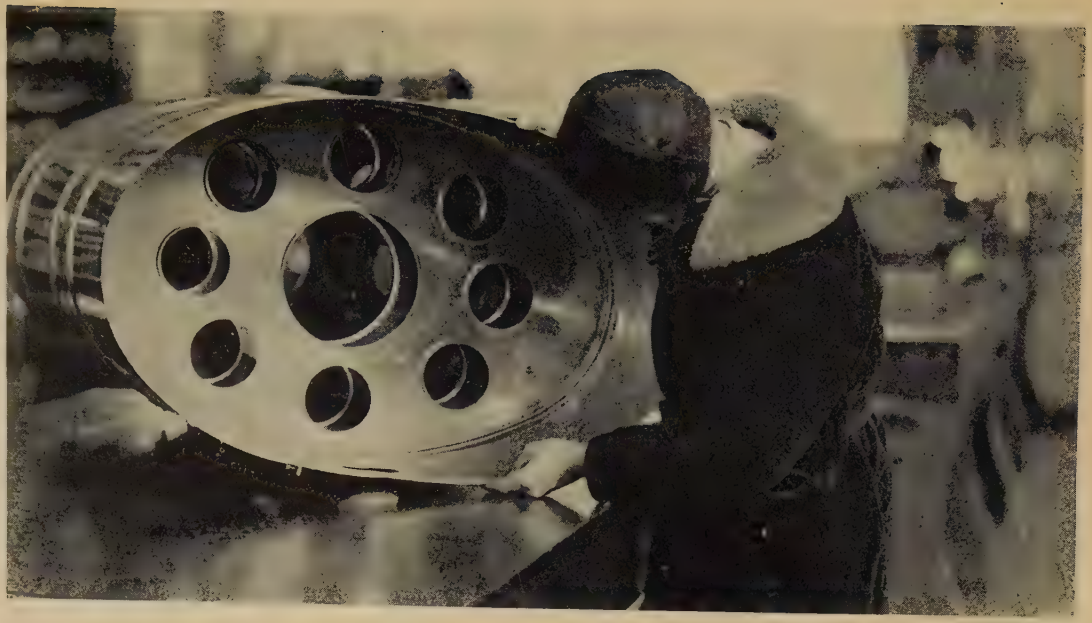
Not far distant was a wing-tip spar already put together and resting on a jig. He took Pat over and let him view it more closely, showing him the gusset plates which strengthened the joints.

"Now," said he, "if you understand how the framework is assembled, we'll go down to the jigs and watch them assemble the wings. As you know, the wing includes three sections: the center section, which later forms an integral part of the main body of the airplane; and the two side sections, which are firmly attached to the center one after they have been assembled. The end sections or tips can be removed if occasion demands. The two outboard motors are suspended beneath the middle section of the completed wing. The gasoline tanks are carried inside the center section."

As they talked they walked along and soon stopped before one of the scaffolds. The boy saw that the thin or trailing edge of the wings was uppermost, while the curved or leading edge was nearest the floor.

"That's because we build up the wings from the leading edge," Mr. Roberts explained. "This scaffold, as you can see, consists of several tiers, one above the other. The workmen stand on platforms above the heads of other workmen and thus are able to reach up to the highest parts."

From the framework they walked to another jig,



Pat lingered a moment longer to find out how the gas tank was formed

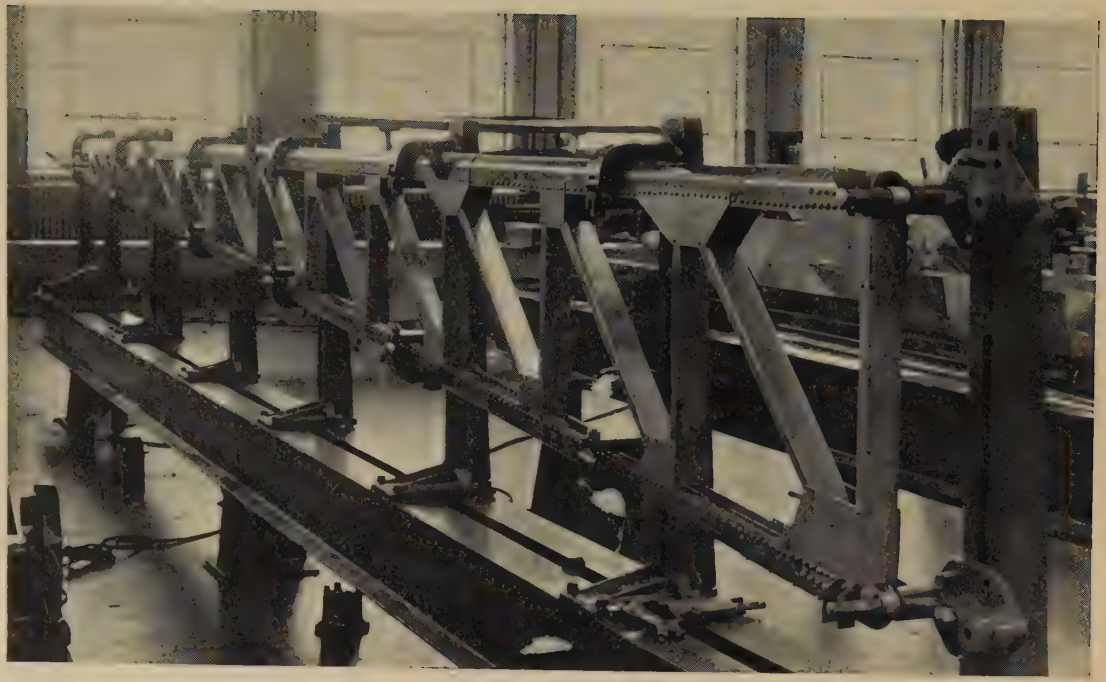
Pat examines the interior of the unfinished fuselage to see how it is put together

Trying out the rudder bar controls

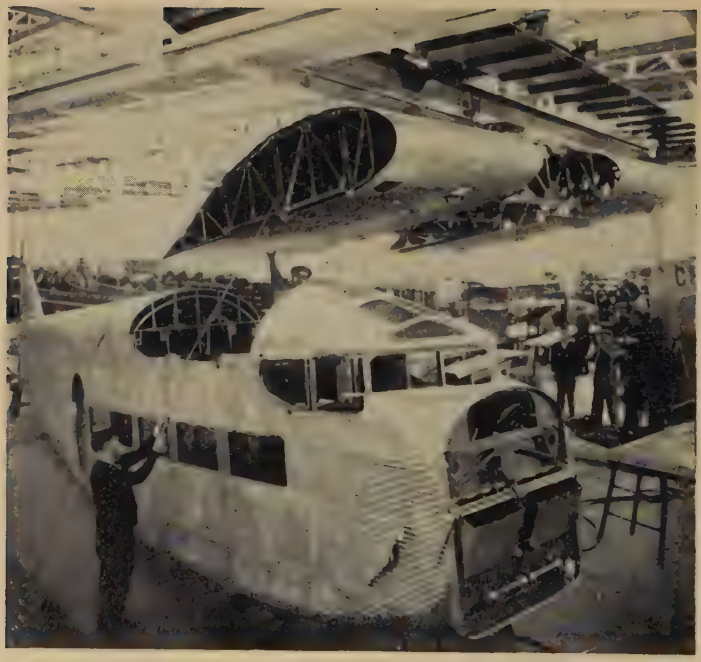
The leading edge panels or "nose formers" are perhaps the most difficult detail parts to fabricate in the entire construction of the plane. The covering of the wings is of continuous strokes of corrugated skin from leading to trailing edges.

The design of the wing necessitates extreme carefulness in forming these parts. Each piece is rolled a number of times and fitted to the form. If not correctly made the corrugations will not match properly with other sections of the covering at their ends.

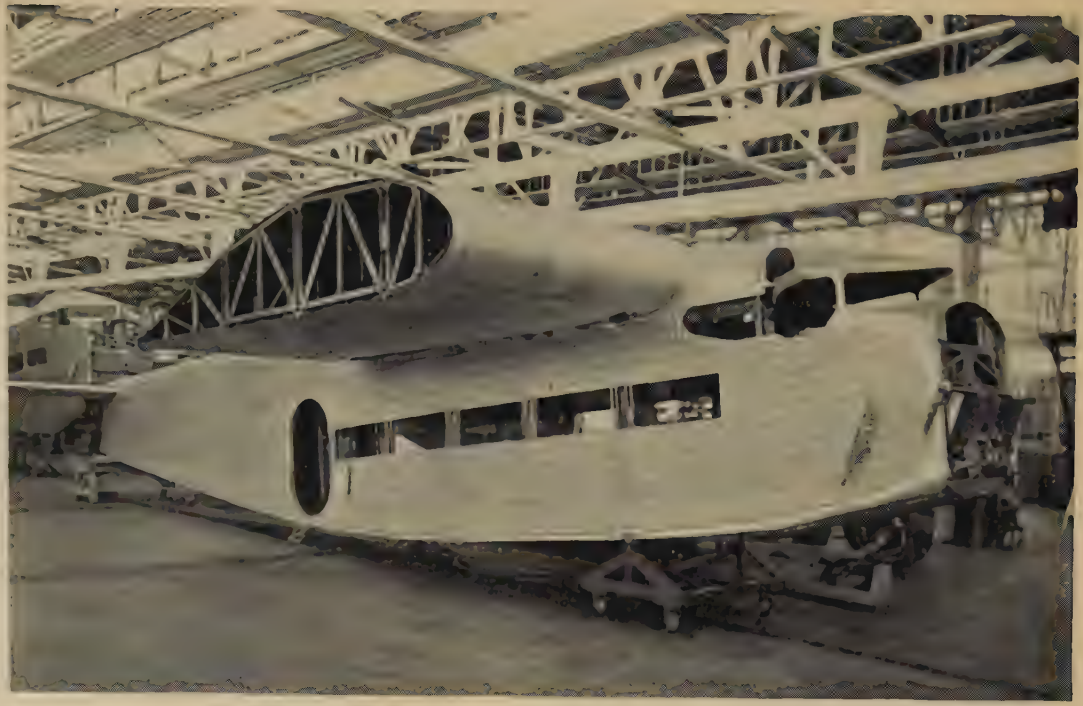
One operator is shown at the rolls while the other is fitting sections to form to determine whether further rolling is necessary.



One of the spars supporting the wing tip



The crane glided across the factory, carrying the section close to the rafters



It settled without a jar upon the shoulders of the fuselage

The elevators are attached to the horizontal stabilizer

equally tall, where a center wing section had been completed to the extent of receiving its wing covering. Pat spied a narrow flight of winding steps on the right of the jig, leading up to the very top.

"I wonder if I could climb up there?" he asked. "I'd like to look down and see how much the wing is curved."

"You mean cambered, don't you?" said his instructor. "Go ahead, sonny. You can't hurt anything."

When the boy arrived on the top platform and turned to look around, he was thrilled to find how far up he was, almost under the very roof. He had not dreamed that the wings were so large.

"That center section is twelve feet wide," Mr. Roberts told him. "And twenty feet long."

After he returned to the floor again they examined the jig where the wing tips were made separately from the center section. The two tips, left and right sides, stood back to back, so to speak, with the cambered surfaces on the outside. In that manner both were assembled at the same time.

Pat wanted to know how these huge sections could be lifted from the jigs and carried across to the waiting fuselage.

"Watch them move that center section," said Mr. Roberts. "They're getting ready to do it right now."

Quickly they got to one side where they could see the whole process. A crew of men gathered about the sec-

tion, as others unlocked the bars that held it in place in the jig. At the signal, "Ready, heave ho!" the men moved it out without the least difficulty.

Pat exclaimed his surprise.

"You must remember," said Mr. Roberts gently, "that the wing must be light as well as strong. Although those sections look large, they are not heavy. One of those wing-tip sections weighs less than five hundred pounds."

Meanwhile the crew of men had brought the section out to a point where it could be picked up by an overhead crane. They set it down easily, and the crane picked it up. The crane glided across the factory, carrying the section close to the rafters. Finally it reached the waiting fuselage, now covered completely with skin and ready to receive the wing assembly.

Workmen guided the section as the crane crept slowly and more slowly toward the exact position for lowering it. When it hung just right, the signal was given, and it descended to its perch. With infinite pains it was arranged in position, and then, as it was released, it settled without a jar upon the shoulders of the fuselage.

Pat was fascinated by the sight. He inquired if the wing tips were brought over in the same way.

"Yes. The crane holds up the tip until it can be fastened securely to the center section. Steel bolts or pins through steel forgings hold the tips to that section, and also hold the central section to the fuselage."

Pat climbed inside the cabin and walked forward to

the pilot's cockpit so as to lift himself high enough to see the joint where the center section rested on the fuselage. Through an unfinished window he twisted and craned his neck until he was able to peer above the wing shoulder. He also could see where the workmen, underneath, riveted the skin in place so that the joint could not be detected. As Mr. Roberts had said, the section became an integral part of the main body.

Afterward he walked about the airplane and watched the process of final assembly. One thing that kept him interested for quite a while was the addition of the tail surfaces. Mr. Roberts explained to him that the stabilizer weighed only about seventy pounds. Pat got up to it close enough to see the saddle on which it rested as it crossed the fuselage. He was just able to reach the elevators from the floor, and he noted how they operated on hinges off the rear edge of the stabilizer.

"I can understand why the elevators move up and down," he said. "I know that you move the elevators one way when you want to rise in the air and when you want to come down, you move them the other way. But I'm not quite sure about the stabilizer. A pilot adjusts it, doesn't he, when he takes off?"

"Well, perhaps I can answer your question best," said his guide, "by asking you if you ever noticed a pilot reaching to fix his controls whenever a passenger moves forward or backward inside the cabin—in other words, when the weight of the cargo changes with reference to the center of gravity?"

"I haven't done enough flying to see that," Pat replied. "But tell me about it, anyway."

"I'll try to express it so you can understand. What he is doing is to readjust the fore and aft stability of the ship. You might say he is trimming the ship. After he gets the altitude he wants, he balances the ship so it won't be any effort for him to keep it flying straight and level. However, if someone in the ship walks from front to back, it is necessary for him to balance it again."

Pat nodded his head.

"If the cargo changed to the front of the plane suddenly, it would make that end bear down, wouldn't it?"

"Yes, unless the stabilizer was adjusted. Another time of adjustment is at the take-off. Then the pilot moves it up, so as to 'blow up the tail,' as they call it."

They walked past another airplane which was almost finished. The landing gear had been attached. A wheel with tire was under the tail, and forward, under the outboard motors, were two larger wheels with tires. Inside the fuselage workmen were preparing the interior decorations and finish.

The boy pointed to the supporting bars which extended from the wheels to the fuselage and also to the motors and wings.

"Are those made of duralumin?" he asked.

"No, sonny. Those are made of chrome molybdenum steel tubing, the strongest steel alloy known. Before being used it is heat-treated. Holes are drilled into each end, and the metal is boiled in oil at a temperature of

350 degrees. In that way, we literally fry out the water that might remain inside the tube, even in the most minute quantities."

"Why do you do that?"

"To insure the tubes against rusting inside. Then we plate them over with cadmium, making the exterior impervious to rust."

At length they reached the far side of the assembly line, and Pat found himself at the opposite end of the factory from the place where he had entered. Workmen were adjusting the three radial motors. He saw how they suspended the big nine-cylinder engines in position and connected them up. He saw them add the propellers, or "props," as they called the sharp, knife-like blades.

"What are those made of?" he asked.

"The props? Oh, they're made of dural," Mr. Roberts told him. "Now, when the men have the controls adjusted, the manufacture of the airplane will be practically finished. The plane is ready for its first test flight when it leaves this point."

"How does it get its gasoline?"

"A truck backs up at this door. A hose is run inside, and the gasoline is fed into the tanks. The truck is not permitted to come inside the factory."

After Pat had walked round and around the airplanes, watching every motion the workmen made, his guide excused himself to return to his duties.

"I've helped you all I can," he said. "Other airplane

factories may differ from this one in some respects, but the general methods are the same. When you understand one, you have a good idea of how all airplanes are made, whether of metal or wood."

"Yes," said Pat, "I know that all planes have to have certain things done to them."

"The fuselage has to be built, the wings have to be assembled, the control surfaces added, the motors supplied, and the controls must be connected up."

Pat glanced up at the factory clock and gave a sudden exclamation of dismay.

"Gee, it's nearly three o'clock."

He had planned on spending part of the afternoon at the library looking up aviation material and had not noticed it was so late.

With Mr. Roberts he walked back to the wing-section jigs. No longer did the clamor and bustle of the factory frighten him. Thanks to his trip through it, he knew what each operation accomplished. Instead of a confused hurly-burly, it had become a well organized process that started from sheets of raw material and continued on through to the finished airplane.

He was ready now to go on with the finished airplane.

CHAPTER TEN

A HANGOUT FOR PILOTS

OVER the doorway was the sign, "Operations Office. Pilots Register Here."

As he read the words Pat felt a little thrill of excitement. It was Saturday morning again, and he was back at the airport.

Pat had looked forward to this moment ever since his visit to the factory. He wanted to meet some pilots face to face and talk with them.

The sky was lowering and dark, and the weather was generally disagreeable. It was one of those days when a pilot has to contend with poor visibility and when ice forms on the wings.

The boy walked boldly up to the door and, before entering, glanced once more at the sign. The door opened into an anteroom. It was the pilots' office. He found there three men, dressed in ordinary clothing, standing about a bulletin board.

One of them, a tall, rangy individual, turned and nodded at him as he came in.

"Hello, buddy. Looking for someone?"

"Yes, sir. I'm looking for the man in charge."

The man peered through a glass partition and shook his head.

"He's out," he said. "And so's his assistant. But one of 'em will be back soon. Have a seat."

Pat sat down and gazed about. Along the opposite wall ran a bulletin board made up of four sections. That about which the pilots were gathered bore the heading, "To-day's Weather Report." They seemed to be much concerned with its purport. The other three divisions were headed, "Local Airways"; "Department of Commerce"; and "Visiting Pilots."

The conversation of the three men caught his attention.

"How's the ceiling at Chicago?"

Someone read, "Eight hundred feet."

"What else does it say about Chicago?"

"Plenty. 'Light snow, visibility two miles, solid overcast. Temperature 37.'"

"What's the visibility at La Grange?" asked another.

Someone read aloud, "One quarter mile," and all laughed.

"It's been a quarter of a mile at La Grange for the last three months," another remarked. "That fellow doesn't know a ceiling when he sees one."

"I hope you don't have to hedge-hop like I did yesterday," said the first speaker. "I was just over the tree tops all the way from South Bend. I picked up some ice on my wings."

"Speaking of ice," added a second, "you ought to have seen what I ran into yesterday. I got into a fog bank thicker'n pea soup and picked up so much ice I had to set down at Sturgis."

"You were lucky to be over a good airport," the third told him. "On my way to Buffalo I picked up a lot of ice, but I couldn't see any field, and it wasn't so hot to set down."

From their conversation Pat surmised them to be pilots, and he was keen to join them. He rose slowly from his chair and walked over.

"Can I see how the weather is?" he asked shyly.

One of the pilots laughed.

"Help yourself, if you can read it. What do you want to know?"

As he drew nearer he saw they were reading typewritten notations underneath a map. The latter was crossed by wavy lines that circled about "low pressures" and "high pressures."

"Do you men have to look at that map before you fly?" he inquired.

"I'll say we do," remarked the man who had greeted him at the door and whom the others called "Bryant." "Every day."

"Why? Does it change much?"

"And how!"

Pat pointed to the words "low pressure area."

"That means air pressure, doesn't it? What kind of a pressure is a low one?"

"Not very nice. But you'd better ask the weather man about that."

"Gee, do you keep a weather man here?"

"Sure thing, buddy. Ask the boss to show you where his cubbyhole is."

The men seemed so friendly and willing to talk with him that he was emboldened to keep on asking questions.

"What's this other map?"

He pointed to a large one that almost filled an entire side of the anteroom.

"That? It's an aviation map of the United States. Did you ever see one before?"

Pat never had. He walked to it and found that he couldn't reach its top even when he stood on tiptoe. Radiating out on its surface toward the east and west coasts were large circles.

"Those tell the distance in flying miles between city and city," said Bryant. "We can check long trips, general directions, and general locations on this map. But for actual flying we use smaller maps which contain more details. Would you like to see one?"

"If you please."

Bryant stepped into the inner office and returned with a handful of folders, each a state map.

"Now, buddy, I'll show you what a pilot uses to guide him across the sky. Your dad has automobile maps, I suppose, when you go on cross-country tours."

"Sure," Pat said quickly.

"Well, this is the same sort of thing made specially for flyers."

He spread out a map on the table and showed how the air routes between important cities were marked by red lines. The correct location of each airport was plainly given by a circle. Also it showed, by means of stars, the emergency landing fields and those that were partially restricted as to use. It even indicated the revolving beacons that lighted the way at night.

Pat noticed lines of red dashes which seemed to run up and down the sheet. On other maps they curved in irregular fashion. Whenever one of these lines arrived at the edge of the paper a number was given.

"Those are not flying routes, are they?" asked the boy.

"No. But they're very important. They show the magnetic declination that a pilot has to compensate for. In other words, the variation of his compass—on the line of flight—from the true north."

"Gee," exclaimed Pat, "that sounds like deep stuff."

"I'll try to make it clearer. You know, of course, that the compass needle points to the north?"

Pat nodded his head.

"Yes, I know that somewhere up in the north is a body of ore which attracts it. And I know it is not at the exact North Pole."

"Sure. You learned that at school. Now, suppose you were a pilot flying between Detroit and Chicago by compass. Could you tell which way was true north?"

"No," answered the boy slowly, "I guess I couldn't."

"Your compass would tell you the magnetic north. But maps are based on true north and south. You would get off your course unless you made allowances for the difference between the true north and the one that your compass showed you. If you didn't, you'd arrive at the wrong place."

"How much difference is there?"

"Well, the map tells us how much correction to make."

He picked up the map of Michigan and showed Pat where the line of red dashes crossed the air trail that stretched between Detroit and Chicago. On the margin Pat read: "2 degrees."

"The pilot must allow for two degrees between Detroit and a point just east of Elkhart, Indiana; and for another two degrees between that point and Chicago. Here's something that may interest you," he went on. "East of Elkhart the compass needle points to both true north and the magnetic north at the same time. It's the only place on any of our routes that this happens."

"Gee, that's interesting!" exclaimed Pat.

He glanced at some of the other state maps.

"I see that the line of red dashes seems to run east and west as well as north and south," he remarked.

"That's because a compass is affected whenever a pilot flies over a region where iron deposits are. Some of the corrections actually form circles on the map around the deposits."

"That would be a swell way to find out where iron is," said Pat. "Do those corrections ever get very large?"

"Oh, yes. Out on the west coast, for example, it is as much as twenty-one degrees."

A rear door opened, and into the office back of the partition walked a man who Pat surmised must be one of the bosses.

"There is Mr. Mounts," said Bryant. "He's the assistant chief of operations."

Soon Pat was seated at the desk opposite the newcomer, looking into a pair of merry brown eyes. They smiled encouragingly as Pat explained his ambition to learn about flying and how he had already been helped on his way by the others.

"So you're anxious to learn something about operations?"

"Yes, sir."

"Well, here's a good place to start. This office is the headquarters of the pilots. We direct their activities from here. Visiting pilots come here immediately after landing and register, just as you would at a hotel."

"Why is that?"

"I'll show you. We'll get the register."

He brought out a large book with leather covers and turned to a page. Pat saw that the date and hour of arrival of each pilot was marked down, also the pilot's name and license number, the license number of the air-

plane flown by him, and its make; the place from which it came and whether it carried passengers; the hour of departure and date, together with destination.

"This book is used as a reference," said Mr. Mounts. "For example, whenever an airplane leaves here and is delayed on its flight we could learn in this book when it started."

Eagerly the boy turned over the pages, looking for the names of famous pilots. He found many listed there, around-the-world flyers, record makers, and trans-oceanic flyers. On the last line he saw entered the name of Captain Frank Hawks.

"Gee, is that *the* Captain Frank Hawks?" he exclaimed excitedly. "The pilot who broke the trans-continental record?"

"Yes, that's the same Captain Hawks. He's over in the hangar now looking at a plane his people have just bought."

Pat's eyes shone.

"I wonder—I wonder if I could see what he looks like. I'd like—I'd——"

Mr. Mounts laughed.

"Come along and meet him," he suggested.

"But—but do you think——"

"That he'll mind? Say, let's try him out. Come along."

CHAPTER ELEVEN

MEETING A SPEED KING

"IT'S like a big garage," said Pat, as he walked with Mr. Mounts to the front of the hangar, facing the flying field, and peered into the interior. The entire face of the building was open. Its doors slid into concealed stalls, and there were no posts or columns to block the ingress or egress even of the largest planes.

Planes of many different kinds and sizes, large and small, were parked inside. Some stood in solitary idleness; on others mechanics were working. Pat had never seen so many in one building. Among them were several trimotor ships like those he saw built in the factory.

At Mr. Mounts's side he crossed the wide floor to the far end. A trimotor plane stood in a cleared space where it was being serviced preparatory to flight. The mechanics were being directed by a broad-shouldered young man whose smile was ready and whose manner was quick and decisive.

He turned, as the two drew near, and recognized the assistant chief.

"Come here, Bill," he called. "I want to show you something."

"That's the captain," whispered Mr. Mounts, as

he waved his hand. Then, aloud: "All right, Frank."

"Gee," whispered the boy, "he looks just like his picture."

Mr. Mounts laughed outright at Pat's enthusiasm.

"Captain Hawks," said he, "I want you to meet a young admirer of yours."

Pat glanced up into the strong, keen face. He felt a bit flustered, but the two aviation men didn't seem to notice it.

"So you're learning to fly, too?" asked Captain Hawks. "How far have you gone?"

"Gee, I'm just beginning," said Pat modestly. "Mr. Mayo told me about the business, and Mr. Stout taught me a lot about why a plane stays up in the air. And last Saturday I went through the factory to see how it's built."

"You're getting a fine start, seems to me. Have you been up in the air yet?"

"Once. Mr. Mayo gave me my first ride."

"That's too bad. I was just going to offer to do that myself."

"Gee," exclaimed the boy, disappointed. "Can't you do it anyway? I don't know anything yet about flying a plane. I mean, the work a pilot has to do."

The boy's face was so wistful that it awakened memories in the heart of the speed king.

"Well, maybe I will. Stick around here close to the ship and when we wheel it out I'll give you a few pointers. I'll even take you up, if I have time."

"Hooray!" cried Pat enthusiastically, while the two men smiled.

He made up his mind not to leave that part of the hangar until the ship was moved out. He waited near at hand while the captain took Mr. Mounts up into the pilot's cockpit for his chat. After a few minutes they returned, and Captain Hawks hurried off.

"Don't stray too far," he cautioned Pat, with a flash of his quick smile. "I won't be gone very long."

"I'll be here," Pat promised.

"Gee," he said, as his friend Mr. Mounts led him toward one of the near-by planes, "I hope he'll have time to give me a few pointers."

"He will," Mr. Mounts replied. "He's going to fix up a diagram of the plane for you so you can understand better how the controls are operated."

"Honest? Won't that be grand?"

"What do you know about Captain Hawks?" asked Mr. Mounts quizzically. "You know he's a speed king, of course; but what else do you know about him? Can you tell me anything about his flying?"

"I sure can," replied the boy promptly. "He's the only flyer, isn't he, who made a record across the continent with an airplane and then turned around and beat his own record?"

"Yes, Pat. He's the pilot who set the transcontinental record from New York City to Los Angeles and back again. He made the record and then he broke it himself."

"I can tell you his time. It was thirty-six hours and

not quite forty-nine minutes from New York City to Los Angeles and back to New York City."

"That's right. His exact time was thirty-six hours, forty-eight minutes and forty-eight seconds. He made it in a Lockheed-Vega."

"Does he fly for records now?"

"He has charge of the airplanes for one of the big oil companies," replied Mr. Mounts. "The Texas Oil Company, I believe."

Pat was almost too thrilled for words at the prospect of flying with such a noted pilot. Boylike, he had worshiped the speed king from that day in June, 1929, when Captain Hawks rose from Roosevelt Field and flew straight as an arrow for the Pacific Coast, rested a short while, and then flew back. The speed had averaged, the newspaper accounts said, 152 miles an hour.

Mr. Mounts brought Pat back to the hangar again.

"Come along with me," he said. "You've got several moments to wait, and I want to show you some planes which will interest you, I'm sure."

CHAPTER TWELVE

TWO FAMOUS PLANES

AS PAT strolled about the hangar with his guide his eyes fell upon a large black trimotor plane which stood proudly near the center of the building. Under its wings and across its fuselage ran big black letters bearing the name "FOKKER."

"That plane looks like it had a history," he said quickly.

"It has. A remarkable one, in fact. That's the plane in which Commander Richard E. Byrd and his companion, the late Floyd Bennett, flew across the North Pole and back to civilization!"

"Gee," exclaimed the boy, "I'd like to look at it!"

"You may. It's resting here waiting for an honored place in the museum."

Pat hurried over to the side of the huge black bird, idle now after its history-making flight over the icy plateaus and wind-swept wastes of the Arctic. He walked completely around it, studying the square lines and the controls. His gaze followed the wires that led back to the elevators and the rudder.

"I wonder if I could look inside," he begged.

"Sure."

The boy opened the cabin door carefully and stepped in. He found the interior now being used as a storage place for the surplus equipment that the plane had carried in its dash to the Pole. Among the things was a pair of skis, about which Pat didn't have to ask. He knew that on ice or snow runners were used instead of wheels.

After he had examined the famous plane to his heart's content he clambered down.

"Can you tell me," asked Mr. Mounts, "anything about the flight this plane made over the Pole?"

"Oh, yes," said Pat. "They left from King's Bay, Spitzbergen. It took them about seven hours to reach the Pole and about sixteen for the round trip. It was the first time an airplane had flown over the Pole."

"Yes. Rear Admiral Peary took more than four hundred days to make the same trip."

"Floyd Bennett is dead now, isn't he, Mr. Mounts?"

"Yes. Do you remember how Colonel Lindbergh flew from New York City to Quebec with a serum for him in an effort to save his life?"

Pat nodded.

"Floyd Bennett was a wonderful chap. He was on his way then to aid the German flyers and Major Fitzmaurice, who were stranded off the Canadian coast on Greenly Island. He flew straight from this airport to Murray Bay, where they took him to the hospital. He was sick when he left here. I saw him go. Bernt Balchen was with him."

"Captain Hawks, I want you to meet a young admirer."

"It took them about seven hours to reach the Pole."

"Commander Byrd named his plane that flew over the South Pole the *Floyd Bennett*," added Pat. "Balchen flew over the Pole with him."

They turned away, and almost instantly Pat's bright eyes spied another interesting ship, not far distant in the hangar. Like the Fokker, it seemed to possess an intriguing history.

It was a single-motored ship, a Stinson-Detroiter, with the lettering *Pride of Detroit* along the fuselage. Its orange paint was no longer shiny, and it had the appearance of a veteran that had passed through many arduous experiences.

"That's the plane that flew around the world, isn't it?" asked the boy.

"It flew almost around the world. Schlee and Brock flew from this airport around the world as far as Tokyo, Japan. They would have crossed the Pacific, too, if they hadn't yielded to the entreaties of their friends and families. It was shipped back to our west coast and flown here from there."

When they reached its side, Pat saw countless names scribbled on the painted exterior by persons in every part of the world.

"Here's one fellow in India," he exclaimed. "And right above him is the name of a girl in Paris."

"That's a habit people have," smiled Mr. Mounts. "Sometimes they try to tear souvenirs off a plane. Mostly, they write their names. Just why, I don't know, unless it's because all of us have a love of adven-

ture; and perhaps these people liked to think that something belonging to them was going around the world with those two famous flyers."

Pat took a stubby pencil from a pocket.

"I've got a love for adventure, too," he said shyly. "I'm going to add my name to all these others. Would anybody object?"

"No. The plane has seen its days of service, and I'm sure no one will care if one more boy adds his name to it."

Pat found a place where he could write without crossing over someone else's name—not an easy thing to find—and wrote boldly: "Patrick Callahan, Dearborn, Michigan."

"What can you tell me about their flight?" asked his instructor.

"Well, first of all, they flew from here to Newfoundland. Harbor Grace was their jumping-off place. It took them about twenty-three hours to fly over the Atlantic."

"That's correct."

"You can see here the names of some of the cities they visited."

On the side of the plane he read several—Munich, Belgrade, Constantinople, Bagdad, Rangoon, Hongkong, and Shanghai.

"It also gives the number of miles they flew—18,410."

"Yes, and it also gives the flying career of this ship—

more than forty thousand miles. Quite a lot for one plane, isn't it?"

Pat nodded.

"I can tell you something about Mr. Stinson, too—the man who built this plane."

"Yes? What do you know about him?"

"He made an endurance record at Jacksonville, Florida, in March, 1928. George Haldeman was with him—you know who he is?"

Mr. Mounts smiled.

"Yes, I knew he flew over the Atlantic with Ruth Elder."

"Well, he was with Eddie Stinson. They were up in the air over fifty-three and one-half hours."

"All right. Tell me about Anthony Fokker, who built that other plane."

He couldn't stump Pat.

"I've read about him, too. He taught himself to fly with a plane he built himself. You know he was born in Java. He's been flying since 1911."

At that moment the boy gave a sudden whoop.

"Say," he exclaimed, "they're taking out Captain Hawks' ship."

Mr. Mounts turned and saw that this was indeed a fact.

"It looks like it's about time for your ride," he said. "We'll walk back and wait for the captain."

CHAPTER THIRTEEN

BANDITS AND BANKING

THE sun broke through the dark clouds overhead as Pat and Mr. Mounts left the hangar in the wake of Captain Hawks's ship. They watched the mechanics crank and start the three motors, one after the other. Before long the stalwart form of the speed king himself appeared, coming toward them across the wide floor.

"Ready and waiting, are you?" he smiled. "That's the stuff. Let's get on board."

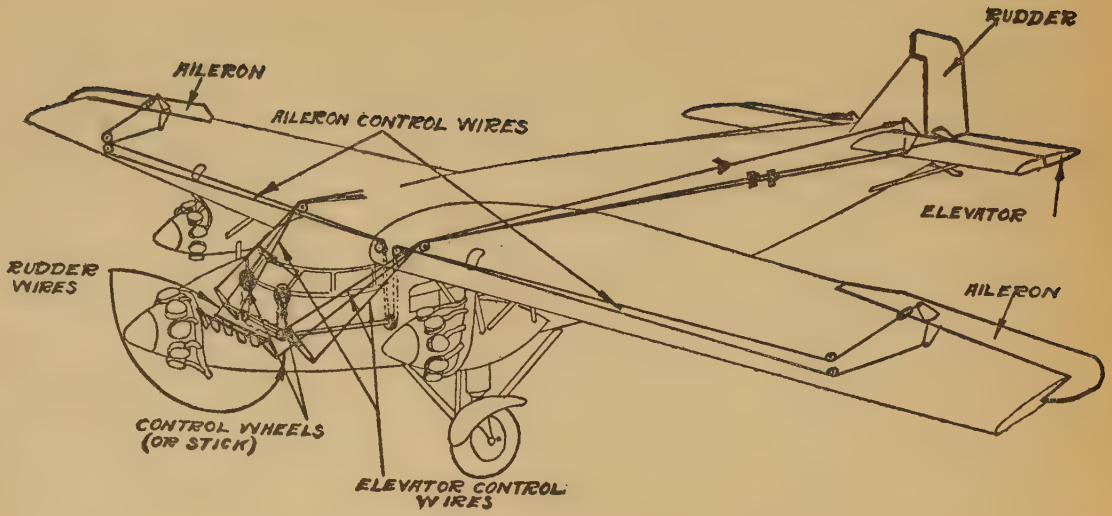
He swung easily into the cabin and walked forward into the cockpit. Pat followed him eagerly, while Mr. Mounts, declining an invitation to accompany them, returned to the Operations Office. Inside the little compartment were two seats. Captain Hawks took the one on the left, and Pat rather diffidently dropped into the one on the right. The pilot handed him a sheet of paper.

"While we're running up the motors," he suggested, "you might be looking at this drawing I made for you."

It was a diagram of a trimotor plane.

"I've marked the control wires so you can see how a pilot operates it," he continued.

Each one was marked as he indicated. Wires ran back



Captain Hawks' diagram of the controls

to the elevators and rudder on the tail; and others ran out to the ailerons on the trailing edge of the wings.

While the boy examined it Captain Hawks checked the motors. At length he seemed satisfied and turned back to Pat with a broad smile.

"As soon as we are ready to start," he said, "you'll have to let my mechanic have that seat. You may sit just outside the doorway where you can watch everything easily."

"Yes, sir," Pat responded promptly. "While we're waiting, will you tell me how you learned to fly?"

"Me? Oh, I'm a graduate of the army school. I took the course at the School of Military Aeronautics at Berkeley, California, and did my first flying at Love Field. That's in Dallas, Texas. Then I studied at the Aërial Gunnery School at Fort Worth and the Pursuit School at Lake Charles, so you can see that I had plenty of training. Afterward I went to the Brooks Field Instructors' School. All that took me about two years."

"Does it take you that long to learn how to fly?"

"Well, I'm still learning. I flew in Mexico for the oil companies for about five years, and some of the most interesting experiences I've had were in that country. On account of the bandits, the oil companies transfer their money in planes, and they have found it much safer."

"Gee, you must have had an interesting time," exclaimed the boy. "Bandits and payrolls! Hot dog!"

For a few moments he was silent as he thought over

the stirring adventures that might befall a pilot in that exciting work.

"Won't you tell me about one of them? Just a short one?"

Captain Hawks grinned broadly.

"We'll take time for just one," he agreed. "I'm going to tell you an incident that will show how valuable the airplane is in transporting payrolls."

Pat's face wore a rapt expression; he sat perfectly still.

"In Mexico," began Captain Hawks, "the men in the oil fields are always paid in cash. They don't use paper money. A payroll of fifty thousand or a hundred thousand pesos means several large bags of gold and silver, which weigh one hundred to three hundred pounds each.

"When so much money is transported by automobile it is not only cumbersome and awkward, but also most easily detected. A great many payrolls have been lost. It was easy for the bandits to spot the payroll car, attack it, and make away with the money, which, of course, they quickly divided among themselves.

"We pilots dreaded the danger of being forced down by motor trouble. Whenever that happened, as it did more often than not, we had to land and make repairs, meanwhile hoping that no bandits were in the neighborhood.

"On this particular day I am telling you about, fifty thousand pesos had to be moved to one of the mines, and I was sent on the job. My plane was an old Hisso Standard which should have been retired long ago.

Before I even started I felt that Old Man Trouble was around, and sure enough, he was.

"It was the same old thing—the motor. Believe me, I was a badly worried pilot as I glided down to the ground to make my repairs. With all that money in the front cockpit I knew I would never get off again if any natives showed up.

"As soon as I came to a stop I looked about, and, sure enough, there stood several natives, and behind them I could see others. I had to think and act quicker than I ever had before. Whatever I did had to be done before they came up. The bags of money were so heavy I couldn't lift them out so as to hide them.

"There was only one thing to do—spread the engine cover over the front cockpit. Then I dropped my tools on the cover and started to tinker with the motor. By the time the first natives came up I was busily engaged.

"It was impossible to tell which natives might be bandits. They all looked alike. I couldn't afford to take any chances. They knew, of course, that airplanes were used for transporting payrolls and probably I had a lot of money with me. But they weren't sure, and so the battle of wits began.

"As soon as the first arrivals reached me I opened a conversation as nonchalantly as though I had no cares of any kind. I even asked them to help me start up the motor. One native inquired innocently if this was a payroll plane. My heart sank 'way, 'way down. But I kept a straight face and answered that I was merely going to

"I'm going to add my name to all these others."

Pat at the stick earnestly inspects the pilot's domain

an oil field in the South 'to bring back a petroleum superintendent.'

"They kept crowding in closer all the time. Here and there a rifle barrel flashed. As soon as my motor was going again I tossed the tools back into the front cockpit. They lay there on the motor cover, which in turn concealed the money bags. Then I thrust a leg into the rear cockpit.

"'But, señor,' asked a native gently, 'the tools? You will fold them up? Yes?'

"I smiled as guilelessly as possible.

"'No, *amigo*. I cannot wait. The hurry is too beeg.'

"'But—señor!' another protested. 'Not so fast.'

"By that time I was at the controls. As I feared, they were getting 'wise.' They conferred together with scowling faces.

"'Out of the way,' I shouted suddenly. 'I go now. Look out.'

"As one of them rushed at me I told myself, it's now or never. I turned up the motor and blew him away. In a trice we were rolling down the field—were off.

"I was barely in the air before I heard the shots—Bang! Bang! Bang! They told me I was being used as a target. But the natives had waited too long, and I didn't care. Once I was up in the air, they hadn't a chance in a thousand of hitting me. My only danger was that my motor might go bad again.

"I prayed fervently that it would keep running until I got out of that region. And it did."

"Gee," exclaimed Pat breathlessly, "that was a close shave for you."

"Yes," smiled Captain Hawks. "But the airplane did the work. In five years down there, carrying payrolls, we didn't lose even one. That speaks pretty well for the airplane, doesn't it?"

Pat's attention finally returned once more to the cockpit.

"Those are the rudder controls, aren't they?" he asked, pointing to the metal foot rests which seemed to swing back and forth as he touched them.

"Yes. A pilot pushes his foot to steer the plane. Would you like a little lesson in steering?"

Pat nodded eagerly. He sat very still and listened.

"Steering a plane is much like steering a boat. If you want to steer a boat to the right, you turn the rudder in that direction. The water hits the rudder on that side and swings the boat around in that direction. That's the way the air acts on a plane. The main difference is that with a plane you have to bank, also, when you turn."

He signaled to the mechanics, who removed the chucks from in front of the landing wheels. Once more Pat felt himself rolling down the field to turn into the wind. This time he was looking down from a high perch beside the pilot, many feet above ground. He turned to peer into the cabin and saw that one of the mechanics had seated himself while another stood in the doorway waiting for Pat to make room.

The boy relinquished his seat rather regretfully, but

soon found that he could see into the cockpit almost as well from the doorway.

Now they were wheeling to face the wind. Captain Hawks "gave 'er the gun." As Pat watched he saw his mentor pull back on the stick, or wheel. Before he realized it the ground was dropping away below.

"Did you see what I did when I lifted her off the ground?" called Captain Hawks.

"You pulled the wheel toward you."

"Yes. The 'control wheel.' Some planes have a rubber grip on the top of a lever, just as this one has a wheel. When we want to ascend we pull it toward us. Do you know why?"

"It lifts the elevators."

"Yes. Let me give you a comparison you will never forget. Did you ever drive a hobby horse?"

Pat smiled. As a little boy he had owned and received much pleasure from one.

"You drove it by reins, didn't you?" the captain went on—"just like the horses on a merry-go-round. Think of an airplane in the same way. You drive it by a stick instead of by reins. You pull back on the stick, just as you did on the reins, to make the plane's nose go up. You push forward on it to make the plane's nose go down."

"How does the stick control the elevators?"

"Your diagram will show you. Do you see the wires running back marked 'elevator control wires'? One of them is attached to each end of a sort of rocker arm near the control wheel. As the stick or wheel moves

forward or back it depresses or raises the elevators through those rocker arms."

Pat nodded. Captain Hawks continued:

"Watch the wheel, now. I'm going to bank."

By that time they were soaring westward over open country. Below, as on his first flight, Pat saw the fields stretching along the roads, hemmed in by fences, with here and there a tiny stream winding in and out.

Captain Hawks pushed slightly forward on the right rudder bar, and at the same time Pat saw him move the wheel gently toward the right. Like a graceful bird the big plane swung around, seeming to pivot on that side. The right wing dropped, while that on the left side rose. Captain Hawks released the wheel, letting it return to neutral position. On and on the plane swept around.

"Now I'll bring it back to level again."

Captain Hawks pushed the rudder bar with his left foot and then released it. They swept forward in normal flight.

"That's how you work the ailerons," he told the boy. "They are flipped up and down by the sideward movement of the stick or by turning the wheel. When you want to bank you lift one of the ailerons by moving the stick or turning the wheel to one side or the other. When you do that you automatically depress the other aileron. Whenever you raise one aileron you depress the other. They work together. Look at the diagram and you'll see how that happens."

Once more Pat referred to his paper, tracing the

aileron control wires from the cockpit to the pulleys, where they divided, one going to each wing tip.

"Perhaps you have tried to run around a corner sometime?" the pilot went on. "At a fast speed, I mean. If so, you found you must lean in the direction you want to turn."

"I found it out when I turned a corner fast on my bicycle," replied Pat. "And when skating around a curve."

"The automobile race track has its bank already built, and so the racing cars don't skid off the curves. But an airplane makes its own bank."

"I know," said Pat. "Banking in a plane is something like swinging around a pail filled with water, isn't it?"

"In a way. That's why you didn't feel any motion. You didn't, did you?"

"No, sir. I didn't even know we were banking until I looked out the window."

The plane seemed to drop slightly, then rise again. Pat had noticed the same thing on his first trip into the air. The "bump" was so faint that it was hardly perceptible.

"Look below," directed the pilot.

Pat obeyed and saw they were passing over a thick woods.

"Those woods explain why we met that bump. Air over woods is cool, and cool air flows downward because it is heavier than warm air. A pilot pays no more attention to them than you would to the irregularities you meet driving your automobile."

Pat nodded. He was not afraid of "air pockets" nor of riding the "air waves." They flew on for a few moments longer before the return homeward was begun. The sky had darkened again, and the sun had disappeared behind the clouds.

Once more they banked and circled while Pat watched the operation and admired the skillful way in which the great bird was swung around. He saw the ground nearing as they glided down and kept his eyes fixed on the control wheel. Suddenly Captain Hawks pulled it toward him as far as he could. The plane skimmed the ground and then settled on the surface, rolling along on its wheels. A few seconds later they came to a stop in front of the hangar.

"That's all for to-day," smiled the speed king. "Did you learn anything on our trip?"

"Gee, watching you work the controls was a fine lesson," Pat exclaimed.

On the ground once more, he turned to the noted pilot.

"Do you mind," he asked, "shaking hands with me?"

A broad grin spread over the speed king's face.

"Certainly not, my boy. Some day I hope you'll get to be a real pilot. Keep on with your studying, learn all you can, and I know you will."

Pat made up his mind never to forget Captain Hawks's advice. He felt the firm handclasp of the pilot. Afterward they walked to the hangar together.

CHAPTER FOURTEEN

PAT FLIES A BALLOON

INSIDE the hangar Captain Hawks bade Pat "Good-bye," and the boy walked on alone toward the far end, planning to return once more to the Operations Office. Near the side of the building he passed a spiral staircase that wound up to a small room, suspended just beneath the roof.

He had not noticed it before and wondered what new adventure might await him at the top of the steps. It reminded him of a secret chamber of which he had once read, located in a castle tower. There was no sign at the foot indicating that admittance was forbidden. As his curiosity overcame him he decided impulsively to ascend and learn the secret for himself.

Within the boxlike enclosure at the head of the flight was a tiny office. Its occupant, at the moment he stepped in, was bending over something that looked like a toy balloon. He seemed to be weighing it. It was much larger than the balloons Pat had known. The boy announced his presence with a friendly "Hulloa" and explained the reason for his intrusion.

"Well, my name is Post," said the man, "and I hap-

pen to be the weather man at this airport. Right now I'm getting ready to take a reading."

"Can—er—may I watch you?" asked Pat. "So I can learn all about high and low pressure areas? You know, while I was waiting for Mr. Mounts down in the office I saw the weather map. What do you do with the balloons?"

"Take readings. You have never thought, have you, that the toy balloons you used to buy at the circus have a useful purpose?"

"No, sir, I haven't," the boy admitted frankly. He stepped forward beside his new teacher, who seemed to be willing to explain the secrets of his work.

"Are you weighing it?"

"That's exactly what I'm doing. If the balloons we use didn't weigh the same, our observations would vary. We inflate them so that their average lifting power is 170 grams. Not quite six ounces. See, this one happens to weigh too much."

He pointed to the scales and Pat saw that the indicator read "180."

"I'll reduce that by letting out some of the gas."

He opened the petcock, and the indicator dropped swiftly until it hovered at "170."

"If there were not enough gas in it, instead of too much, I would simply add more," he explained.

"What kind of gas do you use?"

"Hydrogen."

"It's pretty big, isn't it?"

"It's much larger than the ones you use for playthings. These weather balloons are thirty inches in diameter."

He fastened the neck of the balloon much as Pat might have tied up a football bladder and motioned toward a flight of steps that led upward.

"It's time now to go up on the roof and fly our balloon," he announced.

The boy hurried along behind him. On the flat roof they met Mr. Post's assistant, Dick, who stood beside a tripod on which sat an instrument somewhat like those used by surveyors.

"You may have noticed that this particular balloon is colorless," Mr. Post continued. "That's because the sun has come out again and happens to be shining brightly at this particular moment. The rays gleam from the side of a colorless balloon, and it can be followed by the eye more easily through this instrument."

"Then you use other colors sometimes?"

"Yes, we have four, red, white, yellow and black. If it was dark or the sun wasn't shining, as it wasn't a few moments ago, we would have taken one of the others. Are you ready, Dick?"

"Yes, sir," replied the assistant.

"Then I'll let you show Pat how to take a reading. Here, Pat, hold the balloon for Dick until he wants it. I'll have to go downstairs to my chart."

After he had vanished down the steps the boy asked: "What do you call that instrument? A telescope?"

"No. It's a theodolite. It's a sort of surveying instrument and sextant combined. It was invented for use in making weather observations. As I watch the balloon through it, I can read the angle of elevation as well as that of drift. I read them at one-minute intervals."

"Why?" Pat wanted to know. He wondered how the angles could be used after they had been obtained. The assistant smiled.

"Well, I'll explain, and then we'll let the balloon go up. To start with, we know how many meters a balloon with a lifting power of 170 grams and filled with hydrogen gas will ascend per minute without interference from the wind."

"Oh, I see. You measure how much the wind interferes with it?"

"Yes. It varies from our measurements according to the direction and velocity of the wind at different heights or altitudes. So we measure the variance and deduct the explanation, or reason, for it. In other words, we find out how fast the wind is blowing at certain heights and which way."

"Isn't the wind the same speed all the way up to the clouds?" asked Pat, somewhat surprised.

"Oh, no. It might blow thirty miles an hour at a height of a thousand meters—that's thirty-three hundred feet—and sixty miles an hour at two thousand. If you were a pilot and had the wind at your back you could make better time by going up to two thousand meters, if you knew beforehand that the speed was

much more at that altitude. Or, if you had to fight the wind, you would be able to make much greater speed at the lower level."

"I think I understand," said Pat.

Just then a buzzer sounded.

"Time to start," Dick announced hurriedly. "Let go of the balloon."

Suddenly excited, Pat lifted the swaying ball and let it drift out of his hand. It soared away as if glad to be free and rose in a steady upward climb toward the east.

"Come over here beside me and watch," Dick suggested. "This three-legged stand, you notice, is permanently fixed in place so that it always occupies this position. The instrument turns on its base, but the base remains the same."

While he was talking, Dick revolved the instrument around until it pointed directly at the balloon. With one eye glued to the eyepiece he followed its progress until the buzzer sounded once more. At the signal he glanced at the side of the telescopic device and called down through the open door:

"Ten point six. Sixty-two point one."

"Now," suggested Dick, "run downstairs and see what Mr. Post is doing with these figures. Meanwhile I'll follow the balloon. I'll let you know when it disappears."

Pat turned obediently and ran down the steps. Mr. Post sat before a huge circle, on which he was plotting lines and angles with the aid of a slide rule and pencil.

"Hello, my boy," he said. "Take a look at this plotting board."

Pat peered over his shoulder and was bewildered by the intricate crossing and crisscrossing of lines.

"It's really not so bad as it looks," smiled the weather man. "This circle represents the horizon. Here is north; opposite it at zero is south. East is here and across the circle on the left is west. The circle is divided, you see, into 360 degrees, just as any circle."

"I see," said Pat.

"The degrees are grouped according to sixteen points of the compass. Midway between north and east is the direction northeast. Midway between east and south is southeast. On the other side of the circle we have southwest and northwest."

Pat bent over the big circle and followed his explanations closely.

"Between each of these eight directions is still another one, such as north northeast; east northeast; east southeast; south southeast; and so on. Wait a moment"—he paused hurriedly as the buzzer sounded—"here comes another reading."

After he had noted the figures called down by his assistant he went on:

"What I'm doing here is to chart the exact direction of the wind at different heights or altitudes. By reference to my trigonometric tables, I can also determine the velocity at those heights."

"How long do you have to do this?" queried the boy.

"As long as Dick can see the balloon. The time varies between a few minutes to an hour or so."

"Why do you wait until it goes out of sight?"

"So we can find out how high the clouds are. In other words, so we can find the 'ceiling.'"

"Does the balloon come down after it reaches the clouds?"

"No, it behaves like any other balloon. It sails away until its gas has leaked out, and then, of course, it comes down. Usually it remains up about forty-eight hours."

"Do they travel very far?"

"Some of our weather balloons have been found many miles from where they went up. But here comes another reading. Why not go back up and watch Dick for a few moments?"

Back up the short flight of steps went the boy, just as the reading was called down. For a time Pat stood on the little platform beside Dick. The balloon was still in sight, high in the air to the east. The assistant let him peer through the theodolite eyepiece at the soaring ball, and Pat was surprised to see how its sides reflected the bright rays of the sun almost like a mirror.

During one of the intervals Dick told him more about the strange instrument.

"Do you see that marker?" he asked, pointing a few yards distant on the roof to a permanent concrete projection. The boy nodded.

"That is one end of a straight line that runs through

the theodolite and continues on to that mooring mast you see over across the airport."

"I know," Pat interrupted. "It's where they tie up the dirigibles."

"Yes. We know that the mast is 85 degrees and 39 minutes off the true north. We have this theodolite oriented on that mast, and the straight line that runs from that marker through the base of the instrument to the mast forms an angle with the true north."

Pat nodded a bit doubtfully.

"It's a little deep for me," he admitted.

"Sure. But don't feel badly over it. Some day you'll know all about azimuths and angles."

CHAPTER FIFTEEN

A NEW USE FOR A SOCK

DICK took another reading and called down the figures to the plotting board.

"What are those things?" asked Pat suddenly.

He pointed to a whirling device on the top of a tall rod. It seemed to consist of four cups, each tipped onto its side. The four resembled a pair of crossed dumbbells, such as Pat used in the school gymnasium, except that they were made of metal and the cups were hollow. They revolved around as if pushed by the wind like a couple of weather vanes.

The assistant grinned.

"That looks like a perpetual motion machine, doesn't it?" he said. "Those are anemometer cups, and they revolve when the wind pushes against them. Something like a windmill. They tell us how fast the wind is blowing at this level. In other words, they are a sort of speedometer of the wind."

"Say, it takes a lot to make up a weather report, doesn't it?" Pat exclaimed.

"In the old days before we had airplanes we didn't need all this. But now we have to know more about the wind than we did. Also about humidity."

"Why is that?"

The assistant stopped to take a reading and then explained:

"It's really the amount of moisture in the atmosphere. A pilot has to know all about it. There may be danger of ice forming on his wings in the higher altitudes. We find out all we can about it from a machine called the 'whirling psychrometer.' Don't let the big word frighten you. All it is, really, is two thermometers."

"I know what they are, of course," said Pat.

"The base of one is covered with gauze which we moisten before we prepare to take our reading. Then we whirl the two thermometers about, and the moisture evaporates. The wet bulb is depressed, of course, and gives us a different reading from that on the dry one."

After his explanation Pat didn't ask any more questions for a time. He watched the whirling cups and followed the flight of the balloon, now a tiny speck of light. After a time he went below to watch Mr. Post as he busily computed figures with the aid of the plotting board and those that were called down to him.

"What's this?" the boy asked suddenly, as he discovered another instrument hanging above the weather man's desk.

"That's the most common instrument we use," replied Mr. Post after a hasty glance around. "The barometer. By it we determine the high- and low-pressure

areas. I'll explain about it as soon as I finish my plotting."

When the balloon had finally disappeared Dick came downstairs, and the two men completed their charts. While they were still engaged at it Mr. Post reached across the desk to a radio receiving set and clamped the receivers to his ears.

"Here's our regular report from Cleveland," he announced.

Over the air came a meaningless jumble of figures which he seemed to interpret and understand as fast as they were given to him. On a blank form he wrote down one item after another.

"Now," he said, as he removed the ear phones, "we can get our report ready."

As he wrote he explained.

"We have four main divisions to our airways report," he said. "They are the Sky, the State of the Weather, the Obstructions to Vision, and Remarks. The sky can be either clear, cloudy with scattered or broken clouds, or overcast. The weather, of course, is simple. If we have rain, it might be light, moderate, or heavy. There are three principal obstructions to vision—haze, smoke, or fog. We always include the ceiling, as well as the wind direction and the velocity."

"Now," he concluded, "while Dick takes the report down to the Operations Office for the pilots, I'll explain to you about the barometer. We're fortunate in having

another instrument here that is really an improvement on the old-style barometer, and I'll tell you about it, instead. Here it is."

He brought forward on his desk a boxlike machine with glassed sides, so that Pat could look in and see a narrow arm that stretched across the middle from right to left. On the left it touched a cylindrical chart, where it drew a line, moving automatically.

"We call this a 'barograph,'" Mr. Post said. "It's the same as a barometer except that it not only detects the pressures, but also records them. That cylinder, you will notice, is enclosed in a chart that slowly turns around under the point of the recorder. It is graduated into days, and the hours are marked on the days, so that a single graph, as we call it, includes an entire week. Now let me show you how it works."

In the center of the instrument Pat saw a shining spiral that resembled a series of coils, or a spring.

"Those are the aneroids," Mr. Post told him. "They are nothing but a thin metal bellows from which all the air has been extracted."

"Oh, I see," Pat interrupted, "they hold a vacuum."

"Yes. As the air presses down on them they connect with levers that direct this writing arm. It merely tells how the air is pressing."

"I think I understand," said Pat. "The air presses down on them because it is heavier than a vacuum."

"That's right. That's how we tell what the pressure is, low or high."

"What difference does it make whether it is low or high?"

"Well, perhaps I can explain best by saying that when air pressure is low it indicates unsettled weather, while high pressure generally means fair and clear. That isn't always true, but when we find low pressures moving across the map in our direction and our own pressure gets lower and lower, we can expect weather disturbances."

"Do the pressures move? Or the areas, as you call them?"

"Yes. Here at this airport they generally move from west to east. The reports which we get from stations west of us help us to predict their approach."

"But can the air press down on those cells inside the box?"

"Why not? The box is not airtight. Air penetrates everywhere unless it is sealed against it, you know."

Pat nodded. Yes, he knew that.

"The only thing we have to allow for is the fact that each station is at a different height above sea level. The weather man in Denver, for example, is higher than the one in New York City, because one is in the mountains and the other near the ocean. Air pressure changes one inch for every 925 feet of altitude. So all the stations reduce their air readings to a common level, which is sea level."

Pat had found this so interesting that he wanted to learn still more.

"There's one thing that's got me beat," he confessed. "I saw that machine on the roof that records the speed of the wind, but I don't quite understand how you read it."

By way of answer, his mentor reached down beside his desk and pressed a button. Instantly a new buzzer sounded. It continued to sound at intervals, as they listened. Finally he shut it off again.

"That's how we read it," he explained. "The instrument on the roof has gears which make a contact as they revolve, and cause this buzzer to sound when I turn it on. The secret of telling how fast the wind is blowing is simply by counting the number of times the buzzer sounds per minute. If it sounds ten times a minute, we know the wind is blowing ten miles per hour. Easy, isn't it?"

Pat agreed. He asked another question.

"I've seen down on the field a long narrow thing on a post, blowing about. Something like an old stocking. The men call it a 'sock.' That tells the direction the wind blows, doesn't it?"

"Oh, you mean the 'wind cone,'" said Mr. Post. "That's a weather vane. We call it a 'sock' because, as you say, it looks like one. The reason we have it out there is——"

"I know," Pat broke in. "So the pilots can see it from the air."

"Sure. They couldn't see a weather vane but they can see the 'sock.' It's quite important for them to know

The balloon soared away as if glad to be free

The same kind of airplane that Lindbergh had flown

Nick Mamer is fourth from the left. In the background is the "Spokane Sungod"

which way the wind is blowing when they come in to land."

Pat nodded. He had learned a lot.

"Telling the weather is a big job," he said.

"There's still more," Mr. Post concluded, with a smile. "But I won't tire you out. You've got a good insight into how we do our work. Better than most boys and a lot of men," he added.

CHAPTER SIXTEEN

DASH AND DOT

N-N-N-N-G! N-n-n-n-g ng!"

The monotonous humming noise filled the Operations Office. It reminded Pat of the sound of a foghorn he had once heard across the waters of Lake Erie during a school excursion. Of course, it wasn't nearly so loud. It came from a wide table at one end of the office where Mr. Mounts stood beside another man.

"Hello, Pat. Come over here," the former called.

"Here he is," he continued, as Pat obeyed. "I've been telling Mr. Manning about you, Pat. Shake hands with the boss. He's our operations chief, you know."

Pat shook hands with a quiet, clean-cut young man who impressed the boy at once with his earnestness and serious mien.

"N-n-n-n-g ng! N-n-n-n-g ng!" came the singsong noise again. It seemed to issue from a radio receiving set which stood on the table. The operations chief leaned over it for a moment, listening, and then straightened up again.

"I'm sorry I wasn't in when you called," he apologized. "I was out testing a plane."

"I was sorry, too," Pat replied. "But Mr. Mounts took good care of me."

"How was your ride with Captain Hawks?" asked the assistant chief.

"It was great. Gee, he's a swell guy."

"N-n-n-n-g ng! N-n-n-n-g ng!"

The two sounds, the first one long drawn out, the second a sharp staccato, filled the little office. Pat's curiosity got the better of him.

"Is that a signal of some kind?" he asked.

"It's a radio beacon," replied Mr. Manning. "When you came in we were listening in on it through this receiving set."

"I've read something about it. Isn't it the signal a pilot hears when he's flying?"

"If his plane is radio equipped. Use of the beacon is one of the most important developments in flying. It's very useful to the transport pilot, because it helps to guide him on his course."

"How does it do that? I couldn't understand the article I read. He hears it when he's on the right course, doesn't he?"

"Not that particular one. When he hears a long dash followed by a dot he knows he's north of his true course. If he happens to be too far south he hears a dot followed by a long dash. That's true, you understand, when he is flying east and west. Listen and I'll show you the difference."

He stepped to the table and twirled the dial of the

practice set. There was a brief sound of static, then silence. Suddenly over the air came the signal:

"Ng n-n-n-n-g! Ng n-n-n-n-g!"

A smile crept over the boy's face. The difference between the two sounds was very plain.

"When he's on his course," Mr. Manning continued, "he hears a long dash. The two signals are blended together into one. Listen again and I'll show you."

Once more he twirled the dial, and soon came the report:

"N-n-n-n-g! N-n-n-n-g!"

"The pilot who uses the radio beacon has head phones on his helmet," put in Mr. Mounts. "Sit here at the table and try on our set. I'll find the signals for you."

Pat was glad of the opportunity. He settled himself comfortably in the chair and adjusted the phones. One after the other he heard all three signals. After he had finished, Mr. Manning motioned for him to keep listening for a minute. Suddenly the air seemed to clear, and a voice came across it to him. It was a weather broadcaster, giving the important features of the weather conditions.

"A pilot receives such a broadcast every half hour," said Mr. Manning, as Pat rose from the table. "It is another big help for flying made possible through the use of radio. If he finds out that conditions are impossible just ahead he can look around for a landing field instead of going blindly on."

"How far can a pilot hear these signals?" asked Pat.

"The Department of Commerce plans to have directional beacons, as they are called, at intervals of two hundred miles. After he leaves an airport a pilot follows the course indicated by one beacon until he gets halfway to the next station, when he follows the next beam."

"Is it possible for a pilot to talk to the ground by radio?"

"Oh, yes. If the plane is equipped with a radiophone the pilot can plug in on the set on his instrument board and either send or receive. On the Boeing System, which flies between Chicago and San Francisco, all of the pilots can talk with the ground stations, as well as from plane to plane while in flight. It was the first system to install the service."

"Did you ever hear of a time when the radio actually helped out a pilot through a storm?"

Mr. Manning smiled at the question.

"It has proved its value many times. I might tell you about the first case I ever heard."

"Please tell me," Pat begged.

"It was on the Pan-American Airways—you know who they are, I suppose. Colonel Lindbergh made them famous when he flew on one of his Central American jaunts. This particular day one of our trimotor ships was flying from Tampico to Mexico City with ten passengers on board. Before starting the pilot received an all-clear weather report from the company's central weather station at Mexico City."

The little office had grown quiet. Everyone was listening to the story.

"Two hours out, after the plane was coasting down the interior, it received a storm warning. A twister was sweeping directly across its path. It was extremely dangerous for the air liner to proceed."

"What did the pilot do?"

"The central station signaled him, while the plane was still more than two hundred miles away, to land at Field A and await orders. In a few minutes the reply came from the radio on the plane: 'We are in the mountains. Will land as soon as possible.' After a tense wait the message came: 'Am landing at Field A.'

"They waited for about fifteen minutes, and then came a faint signal, gradually increasing in strength: 'Landed safely. Awaiting orders.' The pilot had rigged his antenna from the plane to a tree and was again in communication with the base."

The outer door opened, and both men turned quickly.

"Hello," said Mr. Mounts, "here's your passenger now."

Mr. Manning stepped forward to greet the newcomer, a stocky, broad-shouldered man who looked even heavier in his extra clothing. He was dressed for cold weather. He wore a leather flying coat with fur collar and a warm helmet. In both hands he carried cameras and photographic equipment.

"Mr. Manning is going up to get some pictures from the air," Mr. Mounts told Pat. "That man who just en-

tered is Bill Kuenzel. He's the chief staff photographer for one of the Detroit newspapers and made one of the first, if not the first, pictures ever taken from the air."

"When was that?"

"In 1911. Walter Brookins—you've heard of him, I guess, one of the first pilots who worked with the Wright brothers—took him up one day when Brookins was in Detroit."

Pat looked wistfully at the little group of men.

"How would you like to go up with them?" asked Mr. Mounts suddenly.

"Grand!" exclaimed the boy. "I wonder if I may."

"I'll see."

The assistant chief walked over to the others and conferred briefly. Mr. Manning nodded to Pat.

"Come along, young man. You'll have to put on some warm clothing, because we're going high. Two miles up, at least."

"I'll dress him," promised Mr. Mounts. "Come, Pat, and see what we can borrow from the pilots' lockers."

In a shorter time than you could imagine Pat was rigged out from head to toe in warm outer garments that were all too big for him but which made him feel very comfortable. Mr. Mounts came out to see them start. Two men dressed in mechanics' overalls also accompanied them. One of them, Pat learned, was named "Jerry."

"I've asked him to sit beside you and answer questions," Mr. Mounts explained.

"Gee," cried the boy, "you think of everything!"

CHAPTER SEVENTEEN

A GOOD TAKE-OFF

THEIR plane waited on the concrete runway directly in front of the office. The tractor which had hauled it from the hangar was just leaving. One of the mechanics went up into the cockpit to turn on the gasoline. The other, standing on the ground below the motors, started to prime them with a small pump. Mr. Manning and the photographer climbed into the cabin while Pat waited outside with Mr. Mounts.

"I suppose you've seen them crank up the motors of an airplane before, haven't you?" asked the assistant chief.

"Yes, sir. They use a long crank which they stick up into the motor and then wind it up."

"I thought you must have seen it done many times. While the boys are getting them started let's get back out of the way and talk."

Pat's keen eyes noted every detail, even as they chatted.

"Does it take very long to learn to be a mechanic?" he asked.

"It does—to be a good one. You can make a pilot in

a couple of years, and it takes just as long to make a good mechanic."

"Why is that?"

"Well, an airplane mechanic is a master of many trades. He must be a welder, a riveter, an electrician, he must know engines, and lots of other things. An aircraft mechanic must have a year's training on actual servicing of planes before he can get a license, and an engine mechanic must have two years' experience with internal combustion engines."

"Does an aircraft mechanic have to get a license?"

"Sure thing. Just like the pilots. The business wouldn't get anywhere, you know, without good mechanics. A pilot would be helpless without them."

By that time one motor was already running. The mechanic removed his crank from a second and called "Contact!" Slowly its propeller began to turn and then to gain in speed.

"For every pilot who flies a plane," Mr. Mounts went on, "there are several mechanics on the ground. The safety of the plane, as well as that of its cargo—human, mail, or freight—depends on their work and skill."

"Why do you have to warm up the motors?" asked Pat.

"Every gas engine should be run in before it is turned up to a high speed. That gives the oil a chance to warm up and circulate around."

"Is it for the same reason Dad warms up the engine of his car on a cold morning?"

"Yes, the purpose is much the same. After the pilot runs up his motor or motors he opens the throttle wide to see if each one functions properly at full speed. It is much better to find it out before he leaves the ground than afterward, you know."

"What is it a pilot checks before he takes off?"

"Why don't you go inside the plane and find out for yourself? Go up in the cockpit and see what Mr. Manning does."

"That's a good idea," said the boy. "Good-bye. And thanks a lot."

He found Mr. Manning already in the senior pilot's seat on the left, buckling on his safety belt. Back in the cabin Mr. Kuenzel was busily engaged in getting his camera ready.

"I wanted to see how you check the motors," he called to Mr. Manning, raising his voice above the engine roar.

The operations chief nodded.

"First I'll check the gasoline," he said.

Mounted on the floor of the compartment directly back of the pilot's seat was a small air pump. Mr. Manning pointed it out to the boy and then indicated two U-shaped tubes, open on one side. They were graduated like gauges, and in them he could see a pink-colored liquid.

Mr. Manning adjusted an air-control valve over the window near his seat and then pulled on the plunger of the air pump, working it in and out a few times, mean-

while watching the level of the liquid. It remained stationary.

He adjusted the valve and tried the same test on the second tank.

"Gas O. K.!" he called. "Now for the R. P. M."

"Do all airplanes use the same kind of gauge?" asked the boy.

"Oh, no. Different planes have different gauges, just as cars do. But all serve the same purpose. A pilot must check his fuel before leaving the ground. Also the oil pressure."

"What else do you check?"

"The proper distribution of the load, for one thing."

"I know," the boy interrupted, "that's where the stabilizer comes in."

"Now," continued Mr. Manning, "let's check the R. P. M. You know what they are, of course?"

"Oh, yes. The revolutions per minute of the motor."

"We check it by means of a tachometer. This plane has three, one for each motor."

He pointed to the dial on the instrument board, and then out the window to another just like it on the engine mounting, where it could be seen easily from the pilot's seat.

"How many revolutions per minute should the motors turn in the air?"

"Well, at full throttle it should be about nineteen hundred; and at cruising speed about sixteen hundred."

He showed Pat three small levers, each topped by a

round ball almost directly in front of the brake lever.

"Those are the throttles," he said. "There is one for each motor. They control the gas, just as on an automobile. Here in front, underneath them, are the three ignition switches. There is one of them, also, for each motor."

The brake lever came in for an explanation. He showed Pat how it controlled brakes on both wheels when pulled back, that of the right wheel only when moved to the right; and that of the left when moved to that side.

Pat's interest was very great. He watched the tachometers while Mr. Manning opened the throttle controls, and one engine after another roared in seeming impatience to be off. He checked the oil pressure and temperature, showing Pat the instruments for each, and then with steady speed taxied along the runway. When they reached the end he ran up the motors a second time and then turned around to face the wind.

"A second check is always a safeguard," he told the boy. "Before we turned I looked to see that no other plane was coming in. Landings and take-offs are made in the same direction and a pilot should never take off unless he is sure that all is clear. If it is, he can open the throttle carefully and 'give her the gun.'"

Pat looked up and saw that a mechanic was waiting in the aisleway.

"It's time to leave," said Mr. Manning. "Go back into the cabin and watch Mr. Kuenzel for a while. Jerry

is coming with us, also, and he'll tell you anything you want to know."

The boy stepped into the cabin and nodded to Jerry.

"Watch close," suggested his new mentor, "and you'll see a good take-off."

Already they were racing along smoothly as in a car.

"Keep your eyes on the pilot," Jerry went on. "He's lifting our tail now."

"Yes," Pat exclaimed. "He's pushed the wheel forward."

"That puts the ship in flying position. When a plane is going straight and level in that position, it will take itself off."

"How do you know that your speed is right?"

"A matter of training, my boy. A pilot never does it twice the same way. When a boat captain brings his ship into the dock he knows instinctively the right time to nose her in."

Pat glanced out the window and saw that they were rising swiftly above the trees and buildings.

"We're off," he cried.

Jerry smiled.

"The chief always makes a good take-off," he said. "You never see him climbing too fast or slipping or veering off to the left or right."

"What's hard about a good take-off?" asked Pat.

"That's like asking the secret of a good drive off the tee at the golf links, Pat, and you, being a caddy, ought to know what that means. There are so many things

that enter into it. But if you take off straight and level, with plenty of speed, you've got more than half of it."

He paused briefly to emphasize his point.

"That's a good rule to remember when flying, too. Fly straight and level with plenty of speed. Remember, speed is always safety when you're flying."

"How can you tell when you're going straight and level in the air?"

"Keep your eye on a point on the horizon and hold the nose of the plane on it. No matter how high you may be, a straight line from your eye to the horizon is level."

CHAPTER EIGHTEEN

TWO MILES UP

THEY mounted upward in spiral fashion, making altitude constantly as the huge plane banked and turned in wide circles. Pat divided his attention between the altimeter on the instrument board, where he watched the height, and the cabin window, through which he watched the gradual retreat of the ground.

The needle crept steadily around the dial, registering in thousands of feet.

"It's simply a refined barometer," Jerry told him. "You know what that is, of course."

Pat explained that he had seen both the barometer and barograph in the weather man's office.

"Then you understand how the atmosphere presses on an aneroid cell in which there is a vacuum. The altimeter works the same way except that it tells us how high we are, instead of the degree of pressure."

All this was clear to the boy, thanks to his visit with Mr. Post.

"I think I see," he said. "The higher we climb, the less the air pressure is. As the pressure gets lower, the altimeter needle swings around."

"There's one thing you should remember about the

altimeter," added Jerry. "Since it works by atmospheric pressure it is subject to the changes due to temperature. It usually reads lower in summer and higher in winter. When the weather is bad and the barometer falls, it will read high, and just the opposite when the barometer rises. In that way, the altimeter can be used as a sort of weather prophet."

"I wish you'd explain something else to me," Pat asked. "I can understand how an automobile speedometer works, because it is controlled by wheels on the ground. But what is it that makes the air speed indicator work when the plane is flying in the air?"

He pointed to the air speed indicator at the top of the instrument board as he spoke. Jerry smiled.

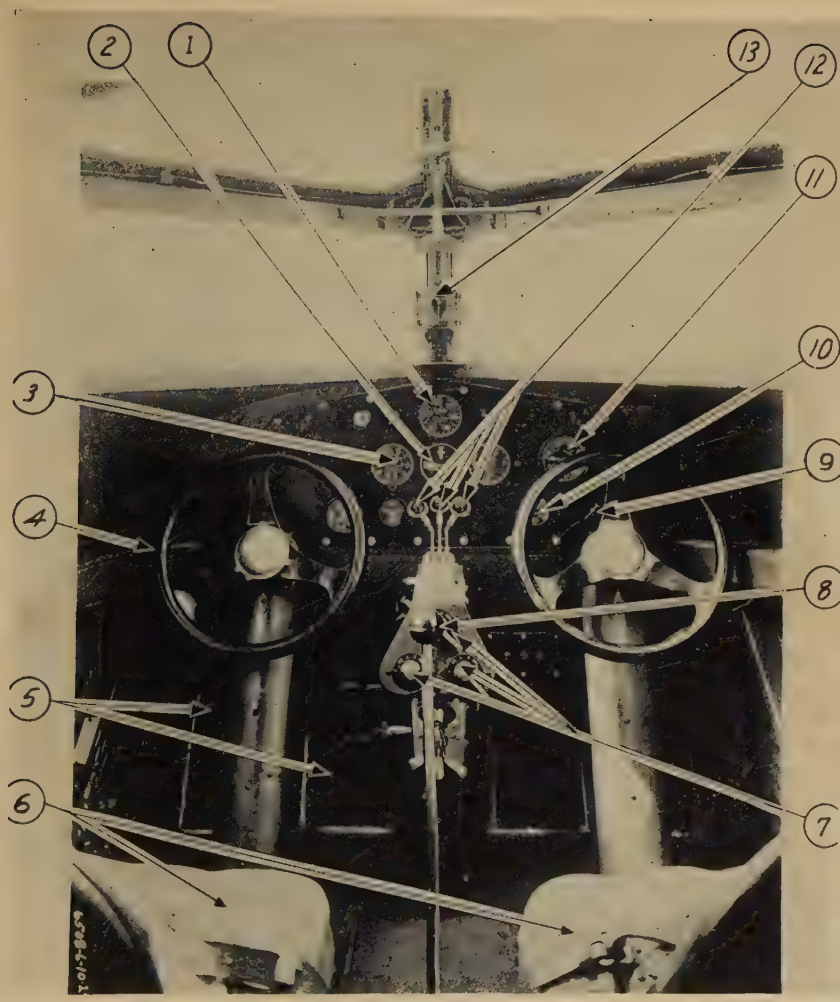
"That's a fair question," he said, "and I'll answer it for you. You understand, don't you, that it tells us the air speed and not the ground speed?"

"What's the difference?"

"Suppose you are flying at a rate of one hundred miles an hour. That would be your air speed, and yet you might be fighting a head wind of fifteen miles an hour. In that case, you would be going over the ground only at the rate of eighty-five miles an hour."

"Sure," Pat agreed. "I see what you mean."

"Well, this indicator is connected with what is called the 'Pitot-Static tube.' It really consists of two tubes, and they are located on this plane on the left wing, ahead of the leading edge. The end of one is open to the air and receives the full impact of it. The other is closed



IN THE PILOT'S COCKPIT

1. *Air speed indicator*
2. *Turn bank indicator*
3. *Altimeter*
4. *Control wheel*
5. *Rudder control pedals*
6. *Pilots' seats*
7. *Ignition switches (one for each motor)*
8. *Brake lever handle*
9. *Oil pressure gauge*
10. *Oil temperature gauge*
11. *Tachometer*
12. *Carburetor throttle controls (one for each motor)*
13. *Magnetic compass*

Photo. Courtesy Detroit NEWS

A CONTRAST IN AIR-CAMERAMEN

LEFT: Walter Brookins, Wright Pilot and Bill Kuenzel, in 1911 when latter made one of first pictures ever taken from an airplane. RIGHT: Mr. Kuenzel and his outfit.

in front and has small holes some distance back from the end. It is a sort of suction tube and transmits the static pressure of the air only. All we have to do is measure the difference in the pressures of the two tubes and we know how much our air speed is."

"How can you tell what the ground speed is?"

Jerry pointed out the window.

"You know how far it is from Dearborn to Detroit, don't you?"

The boy nodded.

"All a pilot has to do is take out his watch and time himself between two landmarks where he knows the distance intervening. Say it is ten miles, for easy figuring, and the plane covers it in six minutes. There are sixty minutes in an hour. Ten times sixty is six hundred. Divide by six and you have one hundred miles per hour."

Up and up soared the plane, winding in an ever-ascending spiral. Every time Mr. Manning swept her around in a curve, Pat leaned forward to watch an instrument in the center of the board.

"That bank-and-turn indicator is a handy thing, isn't it?" he said finally.

"It's a big help to a pilot. So long as that ball remains in the center of the dial, he knows he's banking correctly."

"What is that little pointer at the top of the dial?"

"That's the turn indicator. It shows the direction and rate of any deviation from a straight flight. The

little ball at the bottom shows whether the plane is being properly banked on the turns. That instrument on its right is a climb indicator. It tells us how fast we climb. And now, why don't you watch the picture man a while?"

Pat turned. At the rear end of the cabin sat Mr. Kuenzel, facing the door of the cabin, which had been opened and fastened. He was braced firmly and had his camera already in position.

"I will," said Pat. "I've wanted to see how pictures are made from an airplane."

He made his way along the aisle to a seat near the photographer, who grinned a greeting.

"Aren't you afraid you'll fall out?" asked the boy. "I would be."

"Oh, this isn't anything," the camera man told him. "Wait till the plane banks on this side and I sit here looking straight down through space. That's when you get a real thrill."

"But why do you keep the door open?"

"So I can get a clear view. These pictures I want must be shot from a height of two miles, and we want them as clear as possible."

Pat glanced down and saw the Detroit River below, now shrunk to a narrow stream. Tiny specks like insects could be seen on its surface, growing smaller and smaller as the plane soared upward.

"That camera looks a lot different from ordinary ones."

"Aërial photographs can be made with ordinary cameras," Mr. Kuenzel replied. "This outfit, however, happens to be made especially for this work. You see, there are several points of difference between taking shots from a plane and with a kodak on the ground."

"Sure," said Pat. "In a plane you and the camera are moving at a very fast speed."

"Yes. Much faster than the object you are going to photograph. And you can't focus your camera. This camera has what we call a 'universal focus.' It's set for infinity. It's as good for one mile as four."

"How much country can you get in a single picture from up here?"

"Well, that depends. I've made an eight-by-ten negative that took in four hundred square miles, and you could recognize certain landmarks on it distinctly. That brings up another point of difference. Did you notice I'm not using plates?"

Pat nodded. Mr. Kuenzel continued:

"Plates are not fast enough. During the World War, we had to get along with them. But a young man named Sherman M. Fairchild became interested and after the war he developed this camera. Instead of plates it uses films which are loaded in a magazine. I can take one hundred and ten exposures before I reload. The roll only weighs three pounds. And you know how bulky plates are."

"They're easy to break, too, aren't they?" Pat chimed in.

"I'll say they are. Also, this film is panchromatic—that is, it is sensitive to color. Some colors, when photographed by an ordinary camera, look black. By using this film and a filter on the camera, we are able to pick out the different objects so that they will show distinctly. Otherwise, they might blend together on the picture."

Pat turned and glanced down for a moment.

"Airplane pictures have to be made very fast, don't they?"

"Like the flicker of an eyelash. I've heard of a test in which air pictures were made above the barracks at Fort Leavenworth, Kansas, and twenty-nine minutes later were in New York City, Chicago, and Kansas ready for reproduction."

"Jiminy crickets!" exclaimed Pat. "How did they do it?"

"We have equipment now for quick development of pictures on airplanes. In that test the finished pictures were dropped from the plane to the ground within nine minutes after they had been shot. From the ground station they were transmitted to the cities by telegraph."

"How high up can pictures be taken?"

"I must tell you about Captain A. W. Stevens of the army. Did you ever hear of him?"

Pat shook his head.

"He's the head of the photographic branch of the Air Corps. He has taken a picture from six miles up—including the whole city of Dayton, Ohio—in a single

exposure. Also, he has taken a picture two hundred and twenty-seven miles away. Think of that!"

"How did he do it?" asked Pat, much interested.

"He made it on films that were sensitive to the invisible infra-red rays of light. The human eye can't see such a distance because of smoke and haze, but those invisible rays will penetrate. From a place in southern Oregon, he flew into the air and pointed his camera north. He took picture after picture without seeing what he was shooting at, because it was so far away. When he developed them, he found mountain tops miles away which could be plainly distinguished. Among them was Mt. Rainier, two hundred and twenty-seven miles distant in Washington State."

"What is the record for pictures taken in the air?" Pat inquired.

"The highest I know was a little more than seven miles. Captain Stevens made that picture, also."

"Do you have many exciting adventures taking pictures for the newspaper?"

Mr. Kuenzel laughed.

"You could hardly call them exciting. So far as I know, our newspaper is the only one in this country if not in the world that has this equipment and uses it exclusively for newspaper work. It is very useful. Do you remember the day they dedicated the big zeppelin hangar at Akron, Ohio? I got my orders to go down and get pictures in time to leave Detroit at one o'clock. We were down there by two-thirty, got our pictures,

and were back in Detroit developing them by six."

Pat lingered for a few moments longer while Mr. Kuenzel showed him how an aërial camera is suspended from the cabin ceiling so that all the photographer has to do is to point it on the desired object.

"Some aërial cameras," he explained, "have as many as five lenses and can take five pictures at once, all at different angles. The pictures are matched together by an invention known as the 'transforming printer.'"

He showed Pat how pictures that were being taken for map purposes were made straight down, sometimes through a hole in the cabin floor; while the usual aërial photograph was taken at an angle to cover more territory. At last he looked down and said:

"We're about there. At least we've stopped climbing. You'd better go back to your seat by the mechanic."

Pat obeyed and at once looked at the altimeter. The needle rested at a point just past the figure 12. He was twelve thousand feet aloft. More than two miles high.

Objects on the earth's surface far below seemed almost infinitesimal as he strained his eyes to distinguish them. Floating as if in space on a ship that seemed capable of carrying him on and up into the limitless interstellar heavens, he was thrilled as he had never been before.

CHAPTER NINETEEN

RIDING THE CLOUDS

AT THAT high altitude, Pat noticed how much fresher and cleaner the air seemed. He drank it in eagerly.

"How much higher can this plane go?" he asked his companion.

"Their specifications call for another mile. Eddie Hamilton, who flies one of them between Santiago, Chile, and Buenos Aires, across the Andes, has carried a load of passengers without difficulty at more than twenty thousand feet."

"When you get where the air is too thin, the plane has to stop climbing, doesn't it?"

"You have it," was Jerry's comment.

Suddenly the ship, like a great bird, swerved in a wide circle, the left wing swinging up and the right dropping down until Pat could see that the camera man was facing almost directly downward through the open doorway.

Mr. Kuenzel was "shooting" picture after picture. To Pat's inexperienced eyes the work looked particularly hazardous, but the photographer didn't appear to

notice it. He mentioned his fears to Jerry, but the mechanic only laughed.

"When you swing a bucket around you on a string, or even over your head, the water does not fly out of it, does it?" he asked.

Pat caught the correction right away.

"How does a pilot know when he has reached the top?" he inquired, turning back to the plane's operation.

"The ceiling? There are two kinds, you know. One is the service ceiling, the altitude at which the rate of climb is only one hundred feet a minute. Then there is the absolute ceiling, which is a theoretical altitude which can never be reached."

"What's the highest a plane can go?"

"Well, the present record is over eight miles—more than forty thousand feet. But the average plane will stay within half that height."

"How does the pilot know when he gets there?"

"Well, I've never been up so high myself, but I've heard pilots talk about it. Lieutenant Macready—you know who he is, of course—said that his plane swung and rolled, wallowing about as if it were in a trough."

"What a grand view a pilot must get from up there!"

"He said it was wonderful. The earth is like a miniature world, and at the time he was speaking of, the horizon was two hundred miles away."

"What did the sky look like?"

"He couldn't see any stars, but the heavens were very light and bright, not dark blue."

"What's the object of flying so high?"

"During the World War flyers found they had a wonderful advantage when they could get up. These anti-aircraft guns are increasing their ranges all the time and in the next war, if there is one, some prophets say the air fighting will take place at a height of five or six miles, at least."

"Did you ever hear how it feels up in the sky?"

"Cold, my boy. Raw, bitter cold. Sixty and eighty degrees below zero. The pilots' goggles have to be electrically heated to keep off the frost. They wear oxygen helmets so they can breathe."

"That's because the air is so thin."

"Yep. Terribly thin. You begin to get tired because of lack of oxygen."

Pat nodded. He had read of more than one daring ascent and of the special equipment that was required.

"The air pressure is much less," Jerry went on. "Your body and mine are accustomed to a pressure of 14.7 pounds per square inch. Ever since we have been on the earth we have had that pressure. The first reptiles that crept out of the water had to get used to it. But after you fly above thirty thousand feet, you find the pressure is only 2.5 pounds to the square inch."

"That's why a pilot must have oxygen."

"He drinks in pure oxygen, just as he would smoke a pipe. Without it, he would lose consciousness."

The picture making ended at last.

"He got through just in time," remarked Jerry. "Look below."

He pointed out the window and down.

The boy glanced quickly and saw that they were over a snow-white cloud which had drifted between the plane and the ground. Other clouds were visible near by, and even as Pat watched, they mingled with the first one. Suddenly he awoke to the fact that they were sailing over a sea of billowy waves, so dense that the earth was entirely hidden. The effect was an eerie one; the world seemed empty except for themselves and the sun overhead.

Down they dropped, swooping in smooth circles that brought them steadily nearer the surface of the cloud ocean. Pat saw it draw nearer. The tense expression on his face betrayed his excitement. Never before had he been above the clouds.

The clean white waves tossed and surged beneath the plane. Now it was skimming their surface. The world outside became grayish and cold. They were riding in a fog through which the eye could not penetrate.

Down, down they dropped. Without warning they emerged into daylight again. But somehow, it didn't seem as fresh and sweet as that above. He mentioned this to Jerry.

"You're back in the land of dirt and moisture now," the mechanic reminded him. "When you climb above

the clouds, you're out of it. Flying above the clouds teaches us something about our big cities. It gives us an idea of what people breathe."

He paused for a moment, as if recalling something to mind.

"On a clear day, a pilot can pick out a big city by the smoke pall that hangs over it. He begins to see the haze when he's a hundred miles away. All he has to do is point his plane towards it and he will reach the city in time."

As the plane neared the ground both were silent for a time, watching the objects grow larger and larger.

"Now," said Jerry, at last, "I'm going to show you something else. When we started, you remember, I showed you a good take-off. Well, now I'm going to show you how to make a good landing."

"That will be fine," Pat replied. "I've read that landing an airplane is the hardest part of flying."

"Well, it's certainly the most delicate operation. It takes years of practice and training."

Lower and lower glided the plane. The sky had become overcast, noticeably darker than above the clouds.

"What is the secret of a good landing?" the boy asked.

"It's a matter of approaching your field straight and level, neither too fast nor too slow. Conditions may vary according to the load you are carrying and the wind."

"How do you make one?"

"A good landing is one on three points, the two wheels and the tail. You know that already, I guess."

Pat nodded. He had read about it in some of the flying books at the library.

"Well, a trained pilot approaches his field directly, flying at a safe altitude, then closes his throttle and comes down smoothly."

"It sounds easy," said Pat, "but I know it's not."

"No, it takes training. Some beginners overshoot the field. They go over it and have to try again."

"The wind is important, isn't it? Just as in taking off?"

"You bet. We're almost home, lad. We're over the field right now."

Pat peered from the cabin and saw that the plane was indeed circling over the airport in a counter clockwise direction. It flew around in the opposite direction from that traveled by the hands of a clock.

"Watch below," Jerry suggested, "and you'll see the flag."

Pat kept his eyes fixed on the field. Soon he saw the black figure of a man at the end of the runway, who waved a red signal.

"That tells us we can land," said Jerry. "The field is clear."

"What would happen if he didn't wave the flag?"

"The ships on the ground could taxi onto the runway and it would be dangerous for us to land."

By that time the plane was just above the level of the field. It touched without a jar, then settled down into a steady roll toward the hangar.

"It has been a busy day for you, Pat, hasn't it?" greeted Mr. Mounts, as the boy with Mr. Kuenzel, Mr. Manning, and Jerry and the other mechanic climbed down.

Pat gave a tired, happy grin.

"It'll take me all week to write this up in my diary," he laughed. "But I'll be back next Saturday to see you again."

"O. K.!" Mr. Mounts replied. "The latchstring will be hanging out for you."

CHAPTER TWENTY

A BUSY MORNING AT THE AIRPORT

DURING the next week there was a light flurry of snow, but it soon melted, and the first warning of winter's coming disappeared. When Saturday arrived Pat was at the airport bright and early, eager for new adventures. Much to his joy, he found a number of airplanes had come in for a forthcoming aircraft show.

In front of the hangar stood a huge two-motored ship on which white-suited mechanics were busily at work making ready for flight. As Pat walked up he saw that it was taking on fuel from a gasoline truck. It was a biplane, and on the nose he could read the name—"Curtiss Condor."

The wingspread was so wide that he walked from one tip to the other, taking big steps, to estimate how far it was across. As nearly as he could discover, the distance was more than ninety feet.

One of the pilots noted his interest and invited him to look inside the cabin. It was the first time he had seen one built to carry eighteen passengers. The pilot told him that its useful load was more than three tons.

He found that the cabin was steamheated by tiny radiators, a thing that had never been attempted before on an air liner.

Another thing the pilot showed him was the method used for carrying the passengers' luggage. Instead of occupying part of the cabin space, it was stowed away in compartments in the engine nacelles.

After he had inspected the cabin Pat asked if he could see the cockpit. He found to his surprise that it was entered through a door in the floor instead of through the cabin. A ladder led up to the special pilots' entrance from the ground, and Pat saw it was folded back under the ship when it was not being used.

As he stood in the cockpit, he noticed that the column supporting the pilots' wheel was hinged, and could be used from either of the two seats.

"This plane has also a new kind of radio equipment," the pilot told him. "It weighs only a hundred and forty-five pounds and was developed to use a remote control system of trailing wire antenna. This ship is the first on which that equipment was ever installed."

After he stood on the ground once more, Pat examined the tail, attracted by the twin rudders and fins, instead of the single one ordinarily found there. He was likewise interested in the propellers because they had three blades rather than two. Its motors, he learned, were water-cooled Curtiss Conquerors, each developing more than six hundred horsepower.

The name of Curtiss, he knew, was one of those most

highly honored in aviation. Glenn L. Curtiss, the great pioneer, flew from Albany to New York City in 1910, a distance of a hundred and forty-two and a half miles, in two hours and fifty-five minutes, at a speed of fifty miles an hour. Curtiss was the first to construct and fly a successful seaplane. It was called a "hydroplane" and was fitted with a central float or pontoon beneath the fuselage. Next year he built a genuine flying boat, thus fathering the two types which are most used by seaplanes to-day.

"While you're looking at planes," suggested the pilot kindly, "you should see the little brother of the Condor. It's down the runway at the other end."

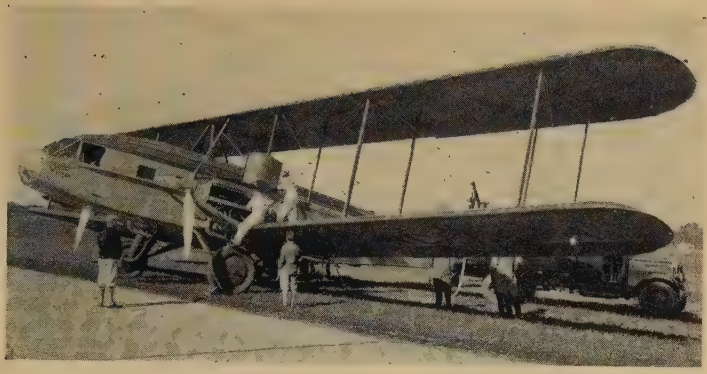
"Oh, do you mean the Curtiss Robin?" queried the boy.

"Yes, I see you know that plane."

"I'll say I do," the boy answered.

He thanked his guide and hurried down to the smaller ship. He had seen the Robin before, but had wanted to inspect one from close up ever since the day it had established a world's endurance record flying above St. Louis. Powered with its Challenger motor, it had soared steadily in the air for 420 hours, 21 minutes, and 50 seconds—more than seventeen days and nights—without a stop. In the cockpit were Dale "Red" Jackson and Forest O'Brine.

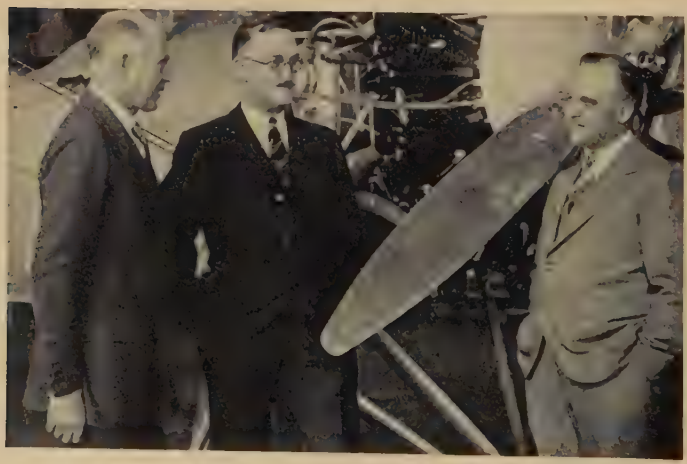
He asked a man standing near if he might climb up and look at the motor. The stranger proved to be the pilot, Mr. Shelton.



A huge two-motored ship on which white-suited mechanics were busy

He had been wishing he could see a Robin

It was the first time he had been so close to a mail plane



ERIK NELSON (left), round the world flier, who flew the NEW ORLEANS around the globe five years ago and who is now sales manager for Boeing Airplane Company; W. E. Boeing (center), and P. G. Johnson (right).

"All right, my boy," he said. "You can peek into the cabin, also, if you wish."

Pat thought he had never seen anything so spick and span and cosy. It was a fine ship, he thought, for the pilot who flew his own plane. Mr. Shelton told him how one just like it had been taken around the country on a pre-scheduled business trip, visiting more than a hundred cities in every state but three.

"And," he added, "it was on scheduled time for every landing and every take-off."

The plane was designed, he said, for a pilot and two passengers. Pat, of course, started at once to ask questions about the St. Louis Robin.

"First," said Mr. Shelton, "in the St. Louis Robin the passengers' seats were taken out to make room for a gasoline tank. On top of the tank was an air-cushioned rubber mattress that served as a bed for the record makers."

He pointed to the side of the fuselage just back of the motor.

"Another change in that Robin was a 'cat walk' which was built from the cabin forward so 'Red' Jackson could walk out on either side as on the running board of a car, and check the motor. It was only about six inches wide and during their flight it got covered with oil and 'Red' said it was 'awful slippery.'"

"Please tell me about the engine," Pat asked.

"Well, on this model it's the Challenger, an air-cooled radial, as you can see, and in some ways it's

different from the other radials. Instead of an odd number of cylinders as in the Wright Whirlwind, the Wasp or the Hornet, it has six. There are two staggered sets of three cylinders each on a double-throw crank shaft."

With Mr. Shelton's permission, Pat looked into the cabin.

"My, it's just like a closed car," he exclaimed.

He went forward to the pilot's seat and studied the controls and instruments. Mr. Shelton pointed out to him the simple, convenient arrangement of the dials, the air speed indicator, altimeter, and tachometer plainly visible above and the oil temperature and pressure gauges below.

Pat thanked him and hurried off, for he had just spied another smart-looking plane parked on the field beyond the hangar. It also was a monoplane, and he knew it was a Ryan Brougham even before he reached it.

Beside it was a man to whom the boy introduced himself. He had already learned not to inspect planes without permission. The man proved to be the pilot, Mr. Young.

Like all boys, Pat knew that it was a Ryan—the *Spirit of St. Louis*—that Colonel Lindbergh had flown on his history-making trip across the Atlantic. He went over the plane from its tail to the Wright Whirlwind motor.

He found its control stick was in the center of the cockpit where it could be reached from either of the two

cockpit seats. To apply the brakes he pressed his heel against a pedal that was suspended below the rudder pedal. On the left of the seat was a second lever for operating the stabilizer.

Pat was interested in the "quick-action toggle switch" seat, as Mr. Young called the pilot's seat. Both cockpit seats were so constructed that one of them could be swung out of the way when not in use. The pilot's seat could be shifted to the center of the compartment directly behind the control stick and locked there. Or it could be moved to one side to make room for the second one. The latter, when not occupied, was folded back against the wall.

"Gee!" the boy confessed, "I don't know which plane I'd like to own."

There were so many good ones a fellow could hardly go wrong. He walked along, eyes alert for new sights. The airport was a busy scene, and he saw many planes of which he had read. After a time he turned toward the Operations Office to seek Mr. Mounts or the chief himself if he was in. A handsome monoplane caught his eye. Its fuselage resembled a long cone, and its wings were brightly painted. It was, he knew, a Lockheed-Vega.

Of all the planes he knew he respected this one for its speed, for it was in such a ship that his friend Captain Hawks had winged across the continent and back again to New York City on his thirty-six-hour flight, averaging one hundred and fifty-two miles an hour.

It was also in this plane, he knew, that Sir Hubert Wilkins had flown from the northernmost tip of Alaska, Point Barrow, across the Arctic Sea to Spitzbergen.

Everywhere about the field was bustling activity. Motors roared, and mechanics hurried hither and thither, servicing the ships. Even as he turned to leave the field, a biplane soared overhead from the west and circled, preparatory to landing.

"Looks like a busy day," murmured the boy.

A bit regretfully at having to leave the scene, he walked toward the pilots' "hang-out."

CHAPTER TWENTY-ONE

A MAIL PLANE FROM THE WEST

"HELLO, Mr. Dean," said Pat, as he entered the Operations Office and found both Mr. Manning and his assistant absent. "Where's everybody?"

"The chief is up with a ship," answered Mr. Dean, who acted as office manager. "And Mr. Mounts is talking with a couple of engineers."

"May I wait here, then? I wanted to ask him to tell me about motors."

"Sure, Pat. He'll be in soon, and he'll be glad to help you."

The boy was examining the big aviation map once more, when the outside door opened, and a stranger stepped in. He was about medium height and unobtrusively dressed, with a pleasant manner and sharp blue eyes.

"Hello, lad," he said.

He turned to the inner door just as Mr. Dean came out.

"I want to register, please."

Mr. Dean handed him the book and he seated himself at the table used for writing.

"Gee," murmured Pat, aquiver with curiosity, "I wonder who he can be."

He resolved to find out when opportunity offered. Meanwhile the newcomer, having signed the book, turned to Mr. Dean.

"My name is Nelson," he announced. "Mr. Boeing and Mr. Johnson are with me. We just got in from Chicago. We want to see Mr. Mayo while we're here, and I wondered if you had a car handy to take us to his office."

"I'll get one."

Mr. Dean hurried out to make arrangements while Pat remained with Mr. Nelson.

"Excuse me," said the boy, "but when you mentioned Mr. Boeing's name I wondered if he was the Mr. Boeing who makes the Boeing airplanes."

"The same man. Mr. Johnson, who is also with us, is president of the company. Mr. Boeing is chairman of the board."

"Do you think—I wonder if he—if they would let me meet them?"

The man smiled at him with a quizzical look in his eyes.

"Of course they will. But why do you want to meet them?"

Pat explained his purpose and told how he had been traveling along the sky highway and of the men who had helped him. Mr. Nelson was much interested.

"As soon as the car arrives come along, and I'm sure they'll shake hands with you."

Pat was overjoyed at the prospect, for he had a great

respect for the Boeing planes and for the men who had made them such an important factor in the industry. He had read once that the Boeing factory in Seattle was the largest in this country that was exclusively devoted to building planes. He had heard of the army and mail planes that bore the Boeing name.

"Yes," said Mr. Nelson as they rode together toward the hangar, "our factory is the largest. It has twelve buildings now; more are being added. Our planes fly the two longest mail routes in the country, you know."

"Where are they?" asked Pat.

"Between Chicago and San Francisco, and Los Angeles and Seattle. By Christmas Day, 1929, our planes had flown eight million miles."

"Gee!" exclaimed Pat, "that's a lot, isn't it?"

"Here we are. And there are Mr. Boeing and Mr. Johnson."

Soon Pat was shaking hands with the famous manufacturer and his companion. After exchanging a few words with him, they climbed into the car and drove away. It was not until after they had gone that he turned his attention to their plane.

It was a combination mail-passenger biplane with green fuselage and gray wings. The pilot's cockpit behind the closed cabin was open. On the side of the fuselage were the magic words: "U. S. Mail." The pilot still sat in his cockpit like a racing driver, helmeted and warmly dressed. An attendant was removing a sack of mail.

It was the first time he had been so close to a mail plane, and he looked over its trim lines with much interest.

"Do all mail planes carry passengers?" he asked the pilot, after the latter had descended to the ground and seemed willing to talk for a few minutes.

"Some lines don't, but all our planes are equipped for them. This one is built for four passengers besides the mail. We've got a big trimotor that can be turned into a regular flying post office. Clerks can sort the letters while it is in the air, just as on a railroad."

"Lots of mail is carried now by planes, isn't it?"

"Well, about two hundred million letters went by air in 1929. And that's a lot, lad, when you remember that we're a young business. It's only since 1927 that commercial planes have been carrying mail."

The pilot opened the cabin door and allowed the boy to glance inside at the comfortable leather chairs and the luggage compartment forward. One of the things that caught his eye was the cabin altimeter, placed there so the passengers would know how high they were. Next he examined the mail compartment. He found that it was lined with metal and covered by a hinged top which was secured in place by heavy leather straps.

The pilot then went to the cabin and brought back a picture. It showed the development of mail transportation between New York City and San Francisco since the year 1850. At that time, shortly after gold had been

discovered in California, twenty-four days were required. Part of the way the mail went by train and part by stagecoach.

Ten years later, about the time of the Civil War, it had been cut to about ten and one half days, owing to the use of pony express riders across the Western plains. By 1876, the year of the Philadelphia Centennial, it was able to go all the way by train, and little more than four days, or one hundred hours, were needed. Faster trains reduced this by fifteen hours, but meanwhile the airplane came into use. Now only thirty hours are required, six more than a single day.

"Thirty hours is not as fast as Captain Hawks flew across," commented Pat as he looked at the map.

"No, but his flight was a non-stop, while the mail is carried from one division point to the next and must be sorted."

The pilot showed him another map of the country divided into three sections. The Eastern and Western parts were shrouded in night, while the middle one was bright as day.

"That illustrates how planes are able to move the mail between the coasts in as fast time as they do," he explained. "Half of the country's air mail is carried on the San Francisco–New York route. Of that route, two thirds is flown at night. Letters can reach either coast from the other with the loss of only one business day."

"Where are the letters sorted?"

"Modern airports are building their own post offices to speed up the handling of the mail. You'll find them at such cities as Atlanta, Cheyenne, Cleveland, Omaha, Newark, Chicago, and several others. They help a lot. At Atlanta, for example, the Chicago plane comes in at 6:25 P. M., the New Orleans one at 6:30, and the one from Miami at 7. Half an hour later all the mail has been sorted, and is ready by the time the New York plane leaves."

"What do the planes do with the mail when they are delayed by storms?" asked Pat.

The pilot laughed.

"Listen, sonny. Ninety-five per cent of the schedules were kept by mail planes last year, rain or shine."

A mechanic arrived to help the pilot put his plane in the hangar, and Pat returned to the Operations Office. He was anxious to find Mr. Manning or Mr. Mounts; and he was eager to learn more about Mr. Nelson, whose face and bearing had attracted him very much.

On the register he read, "Major Erik Nelson."

"Jiminy crickets!" he cried to Mr. Mounts, who had come in. "Do you know who was here just now?"

"Who?" asked the assistant chief, with a smile.

"Major Erik Nelson. He used to be Lieutenant."

"And who is he?" asked his friend teasingly.

"Why, he was one of the army around-the-world flyers. You remember the four planes that flew all the way around in 1925. Isn't it funny that I didn't think

of him, although I heard his last name when he came in?"

"Yes, I knew he was here," said Mr. Mounts. "He's sales manager for Boeing. They're visiting with Mr. Mayo now. Did you have a good chance to talk with him?"

"Yes, but I wish I had talked more with him," murmured Pat ruefully.

"Maybe you'll have a chance later. We'll see if we can find him when we go up for lunch. I want you to take lunch with me to-day, Pat. What do you say?"

"I'll say that's swell," exclaimed the boy. "Gee, every day I spend down here gets more interesting than the last one."

CHAPTER TWENTY-TWO

VETERANS OF THE AIR MAIL

"YOU are using practically all Hornet engines on your mail planes now, aren't you?" asked Mr. Mounts.

They were seated at lunch about a table in a Dearborn dining room—the assistant chief, Pat, and Mr. Johnson.

He found that Major Nelson had gone into the city of Detroit with Mr. Boeing, but as he became better acquainted with Mr. Johnson he liked him more and more. Mr. Johnson was still in his early thirties. Pat acquired a deep respect for him when he heard that the visitor had gone to work in the plant as a draftsman and had risen step by step until he became president.

"Yes, we use the Hornet," answered Mr. Johnson. "Also on our trimotor."

"How much horsepower has the Hornet?" ventured Pat.

"Five hundred and twenty-five. On some of our military models, of course, we use the Wasp."

Mr. Mounts nodded.

"It must be handy for your factory—right in the heart of the spruce country."

"Yes. During the World War it was a big advantage.

Along the northwest coast on the Olympic peninsula there is enough clear spruce to build all the airplanes in the world and then some."

"You make a lot of army planes, don't you?"

"Yes, and navy, too. Pursuit, training, and fighting types, and also large armored attack planes, torpedo planes, and long-distance patrol boats. We delivered seventy-four navy pursuit planes to the airplane carrier *Lexington*."

"How many pilots are flying for you?" asked Pat.

"Well, we have thirty-five planes between Chicago and the west coast, and nine between Los Angeles and Seattle, all carrying mail. In all, we have fifty-five pilots on our staff."

"Several years ago I knew some of your men," said Mr. Mounts. "I suppose you have a lot of old-timers."

"Gee!" Pat put in, "I wish you'd tell me about some of them."

"Speaking of old-timers," said Mr. Johnson, "there's E. Hamilton Lee. Did you ever know him, Mounts?"

"Hamilton Lee? You bet. Just a few years ago the papers back here were full of his doings. But later I lost track of him."

"That must have been the time he dropped food from an airplane to save the lives of those lumberjacks who were marooned by the ice on an island in Lake Michigan."

"Yep, that was the time. There were a number of starving men on the island, as I remember. Six planes

tried to reach them, but Lee was the only one to succeed."

"He must have been a pilot for a good many years," said Pat, keeping up his end of the conversation.

"Since 1913. He's flown more than eight thousand hours, and if you figure one hundred miles an hour you can see he's well on his way toward his first million."

"A million miles!" Pat ejaculated. "What a lot of miles to fly!"

"He's the first ranking pilot in the air mail service. He started flying the mail back in nineteen eighteen, when the service was organized. He flew some of the experimental routes for the government and took out one of the first planes that was ever sent over a mail route."

"He's a real old-timer. Does he still fly on a mail route?"

"Yes," said Mr. Johnson. "Out of Chicago. He flies as far as Omaha on the transcontinental line between Chicago and San Francisco."

"Gee, Mr. Johnson," said Pat, "I wish you'd tell us about some of the others."

The Seattle man grinned at Pat's interest.

"Well," he continued, "there's C. K. Vance. He's been flying only ten years, but in the aviation industry that makes a man a veteran. Like Lee, he's an air mail pilot. His end of the line stretches between Reno, Nevada, and the Golden Gate. He has to hop over the Sierra Nevada Mountains every trip he makes, and

since he started flying he has jumped over them more than two thousand times. During all those trips he has only made one forced landing. How's that for a record?"

"Fine stuff. How long has he been jumping over them?"

"More than seven years. But while we're talking about records I must tell you about the one hung up by Alvo de Garmo and Henry Hoey on our night transcontinental plane eastbound out of Oakland airport. They were flying one of our trimotor ships and took off from the bay shore at 8 P. M. Before 1 A. M., they were in Salt Lake City, Utah."

"Over the mountains—and everything?"

"Yes. They pulled over the summit at twelve thousand feet. They made their best time between Reno and Salt Lake City. That's a distance of four hundred miles. They flew it in a little more than two hours and one half and averaged a hundred and seventy miles an hour. Of course, they had a pretty fair tail wind."

"Where's Harry Huking flying now?" asked Mr. Mounts. "I knew him when he was adjutant at Rockwell Field."

"Harry's flying on the western division of the transcontinental line. Do you remember when he broke onto the front pages of the newspapers six years or so ago?"

"No. What was it about?"

"It was the first night flight from Chicago to Cheyenne. Flying through the dark was a real adventure at that time and big news. Now, of course, trips are made

Elapsed time required for transportation of coast to coast mail from the stage coach to the air mail

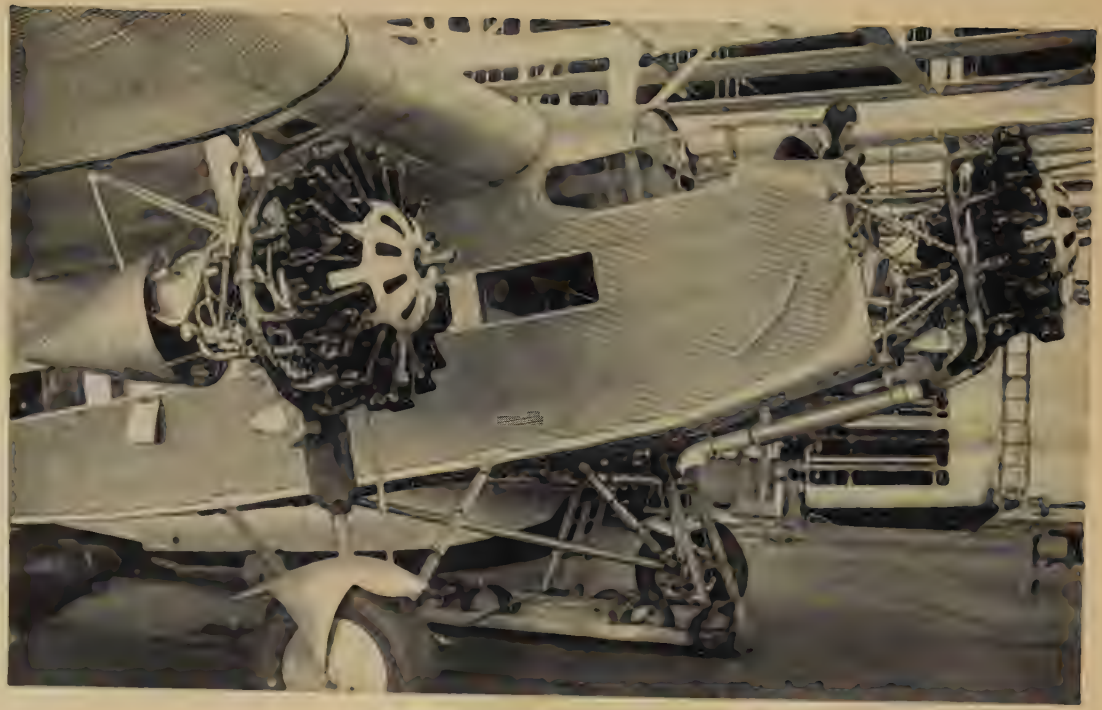
every night from both Chicago and Cheyenne as part of the regular routine."

"In his way Harry's a veteran just like these other fellows. But what was the name of that air mail pilot who brought the first air mail east from the Pacific coast?"

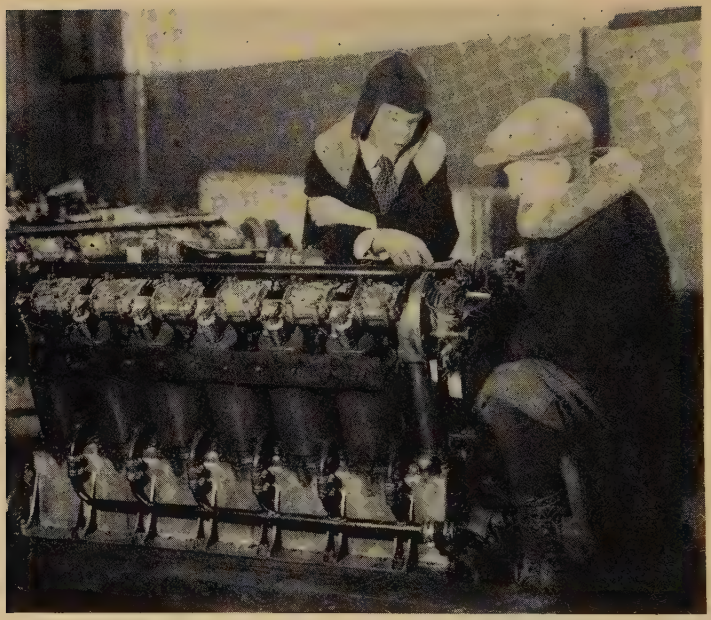
"That was Ray Little. He brought it as far as Reno, and then Jack Sharpnack carried it on to Salt Lake City. That was in September, 1920. Jack also flew the first air express from the west coast in 1927. Do you know what was in the first package?"

"No."

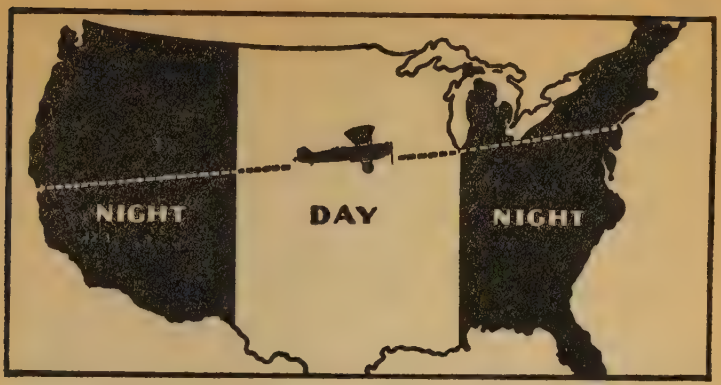
"A piece of bacon. It was addressed to President Coolidge and was taken across the country to him by Sharpnack."



Pat studying motor connections



Pat shows his friend Bob the V-shaped design of the Liberty motor



Half the nation's air mail is flown on the San Francisco-New York route, of which 66 per cent is flown at night, making possible a 30-hour service and the delivery of mail between the two seaboards with the loss of only one business day

Map—Courtesy of Boeing System

"Speaking of night flying, can you remember back when there were no such things as beacon lights?"

"I'll say I can. Two of our pilots helped to erect their own beacons in the early days. Grover Tyler, one of them, is still flying the coast line. Up and down the San Joaquin Valley in California he drove his automobile, with his tools in the back, setting up lights. Art Starbuck helped him. Later, both of them flew over the route at night by the aid of the lights they set up."

"When did the night air mail start, Mr. Johnson?"

"Well, I will answer that by saying that the night air mail route between New York City and San Francisco was opened on July 1, 1924. It's a regular sky boulevard at night. There are tremendous revolving beacons

at intervals of two hundred miles or at the principal landing fields, and in between are smaller ones. On clear Western nights our flyers have caught the big lights as far distant as one hundred miles. On hazy nights they are visible for much less, of course. But they are near enough so that a pilot picks up the one ahead just as the one in the rear is disappearing."

"Can you tell me when the first air mail was carried?"

"Yes, the first letter was carried by an airplane back in 1911. It was taken by Earle Ovington in his Bleriot plane during the Nassau Boulevard meet on Long Island to the Mineola post office, about six miles away. But the regular service began on May 15, 1918, when the Post Office Department borrowed four flyers from the army and sent them out officially. Two flew from Philadelphia, one from New York City, and one from Washington, D. C. The latter pilot had a hard day of it."

"In what way?"

"Well, when he came to the field ready to start, he found they had forgotten to put any gasoline in his tank. President Wilson and the other notables had to wait around for half an hour while he gassed up. He was to go to Philadelphia, but somehow he got lost. He brought his plane to earth in a field near Waldorf, Maryland, after flying in the opposite direction from that in which he was supposed to go. His load of mail weighed exactly four pounds. And that, Pat, was how the air mail started."

CHAPTER TWENTY-THREE

THE WASP AND THE WHIRLWIND

AS PAT and Mr. Mounts, after bidding Mr. Johnson "Good-bye," returned through the hangar after lunch, the assistant chief led him to a small plane which stood in a corner at one side, as if awed by the great trimotored ships surrounding it. He passed below its propeller and looked inquisitively at the boy.

"Can you tell me what sort of motor this plane has?"

It was not a radial type such as most of the planes about the airport had. It was very small compared to them.

"It's an O X, isn't it?" he replied.

"Yes, it's a Curtiss O X, quite a famous motor in its day. It has eight cylinders and develops ninety horsepower. It served many of our training planes during the World War. In fact, more pilots learned to fly behind it than any other, I expect."

"It's water cooled and it's not a radial," Pat remarked.

"That's right. This one has been modernized. The first airplane motor that we know about was built by

the Wright brothers, and the present Wright Whirlwind is a direct descendant. It drove twin propellers. Chains and sprockets were used to connect the props with the engine, instead of the direct drive we have to-day. They wanted their props to run in opposite directions, so they crossed one of the chains."

"It sounds funny now, doesn't it?"

"Yes. But you must remember that even the automobile engine back in 1903, when the Wrights made their first flight, was still being developed. The usual engine had one or two cylinders. By the time of the World War, the airplane had adopted the rotary type because it was lighter in pounds per horsepower. But it led to so many difficulties that the radial and the water-cooled V-type were given preference."

"The Liberty was a V-type, wasn't it?"

"Yes. Another thing that will show you how motors have improved is in the overhaul. We used to overhaul an airplane engine after it had flown one hundred hours or even less. Now we can wait twice or three times as long."

"Why is it that you have to overhaul an airplane engine so much oftener than an automobile engine?"

"But we don't—not in miles traveled. We overhaul our engines after two hundred and fifty hours of service, but that means two hundred and fifty hours at one hundred miles an hour, or twenty-five thousand miles of flying. Lots of automobile engines are overhauled at less mileage than that."

"An airplane engine is what's called high speed, isn't it?"

"No, that's another mistaken idea. Most airplane motors are not high-speed engines at all. What we want is steady operation under a heavy load. You saw how our motors develop sixteen hundred and eighteen hundred revolutions per minute, didn't you?"

Pat nodded.

"Well, if that was all the R. P. M. your dad could get out of the motor in his automobile he would think it was slow. Three thousand R. P. M. is not unusual for an automobile motor."

"I didn't know that," the boy admitted.

"The two are much different. The airplane motor has to deliver nearly its maximum horsepower in flight. An automobile engine is hardly ever called upon to deliver its maximum speed for a long stretch, except racing cars, of course."

Pat smiled in understanding. As explained by Mr. Mounts it seemed quite simple. By that time they had left the small plane and were walking along slowly toward one of the trimotored giants.

"In an airplane engine," the assistant chief went on, "reliability is of prime importance. Weight must be cut down. The engines must be built of the finest materials and workmanship. They are tested exhaustively by the makers long before they reach the airplane factories. They are torn down, the parts are studied, they are reassembled and run, and after all the experimental

work is finished they are tested by the government. It gives them a horsepower rating and an approved type certificate."

"Tell me more about the radial engine," Pat begged.

"It makes a short crankshaft possible—that's one of its good points. It makes cooling by air easy and does away with considerable excess weight."

"Is that a Wright Whirlwind?"

"No, that's a Wasp. Both are radial, you know. That plane over there is equipped with Wrights."

Pat went from one to the other, counting the cylinders. Each had nine, arranged in a circle around a common center, the crankshaft.

"Each cylinder has two spark plugs," Mr. Mounts explained. "Both fire into the cylinder at the same time. Every airplane has two magnetos, also. It is required by the Department of Commerce and is a factor of safety. If one fails, the other is still on the job."

"How much gasoline do these airplane motors use?"

"Quite a bit. All the way from ten gallons an hour up to twenty. But on a mileage basis they use little more gas than a car."

His instructor piloted Pat toward a far door that led into a room Pat had not noticed before. Inside, mechanics were working at benches or tables, and all seemed to be engaged on motors.

"This is the motor repair shop," said the assistant chief. "Here we test them and tear them down. When

necessary we can repair parts and then reassemble them, ready for more service."

"I'd like to see how a motor is tested," Pat requested.

In answer, Mr. Mounts took him to a glass door through which he could peer into a sheltered enclosure. On the far side the room admitted directly to the outdoors, as there was no wall. On a tall stand higher than the boy's head a motor was roaring. Lines ran from it to a partition and passed into a sort of office where two mechanics stood.

Mr. Mounts led the way inside.

"Here's where we watch the performance of the motor out there," he explained. "It is operating under the same conditions it would meet on an airplane. The men are keeping track of the amount of fuel it consumes, the oil temperature, and the horsepower developed."

"Is that a new engine?" the boy asked.

"No. We always test an engine when it comes from the overhaul, just as the manufacturers did when it was built. We check them also at the end of each flight."

"How is that done, Mr. Mounts?"

"Before a pilot prepares for his landing he checks his engines at full throttle and makes a record of the oil temperature, R.P.M. and oil pressure. After he lands, he writes it on his report, so that we know if each engine was performing satisfactorily at the end of his flight."

"Where do you check the motors?"

"In the hangar. The mechanics have regular reports which they fill out. At certain stages in a motor's life they make special inspections of certain parts. For example, the rocker arms are checked after every ten hours of flight."

The boy was much impressed.

"The engine is the heart of the airplane," Mr. Mounts concluded. "Each motor has its own life history just like every plane. A written record is kept of each engine's performance."

"What about this Diesel engine, Mr. Mounts?"

"I think it promises big changes in aviation. The operation of the plane will cost much less. The danger of explosion from gasoline will be removed entirely."

"Is it much different from the radial engine?"

"Well, it hasn't any carburetor, for one thing. No spark plugs are required, and so there is no interference with radio. The weight of the fuel can be reduced and a larger load of freight or passengers carried."

"What other kinds of engines are there?"

"I think we've covered most of them. In the small planes, the engine with four or six cylinders in line is popular. And there are many Liberty motors still in use, especially on mail planes."

While they talked they had strolled back into the hangar. Mr. Mounts planned to show Pat a Liberty motor, of which several were near at hand.

Two men stood beside one of the trimotored ships, and as Pat and his guide drew up, they recognized one

of the two as Mr. Mayo. About the same time he saw them and beckoned.

"Bring Pat over," he suggested.

"Well," murmured the assistant chief to his protégé, "you may get a chance to hear more about Liberty motors than I could ever tell you."

CHAPTER TWENTY-FOUR

BUILDING THE LIBERTY MOTOR

"PAT," said Mr. Mayo, "I want you to meet Colonel Emmons. He was formerly Police Commissioner of Detroit, you know."

The boy shook hands gravely with the tall, broad-shouldered man who stood beside the aviation chief.

"Mr. Mayo tells me you're the boy who's learning all about flying," Colonel Emmons began.

"Yes, sir. Thanks to his help and that of Mr. Stout and all these other men."

"He asked me just now if I would give you a pointer or two."

"That would be fine," smiled Pat. He had read about Colonel Emmons and his interest in aviation.

"Colonel Emmons has been a strong factor in building up the industry," put in Mr. Mayo. "During the World War——"

"I remember!" exclaimed Pat. "I read that during the war he had charge of building the airplane motors."

"We called it the Engine Production Department of the Equipment Division," Colonel Emmons explained. "It was part of the Signal Corps."

"Do you know what they called the engine that was developed during the war?" asked Mr. Mayo.

"Yes, sir. It was the Liberty. Everybody has heard of it."

"What can you tell us about it, Pat?"

"It had twelve cylinders and was V-shaped. It could develop from three hundred and eighty to four hundred horsepower."

"The Liberty motor was used for the combat planes," explained the commissioner. "We had other types for our training planes. There was the Curtiss OX, for instance."

Pat bobbed his head vigorously.

"I know about it," he said.

"It was an old favorite. Then there were the Hall-Scott, the A–7A, the Gnome, the Le Rhone, and the Hispano-Suiza. They were all important."

"I wish you'd tell me about the Liberty," Pat begged. "Wasn't it designed especially for the American war planes?"

"Yes. Credit for its design was given to two engineers —J. G. Vincent and E. J. Hall. They were called to Washington during the month of May, 1917, and asked to design it. They started that same month, and on July 4th a complete engine was delivered at Washington, set up, and run successfully."

"Boy! Wasn't that quick work?"

"It was, indeed. My own department was organized in August, when the real work of producing the engines

started. Our first engine was an eight-cylinder, you know."

"You made a lot of records, didn't you?"

"Well, by May 29, 1918, one year after the first scratch of the pencil toward the design, we had produced and delivered eleven hundred. That was said to be a world's record."

"Tell him how you were going when the Armistice was signed," suggested Mr. Mayo.

"During October, just before it was signed, we were producing at the rate of five thousand motors a month. On the day the war ended, more than thirty-one thousand engines of all kinds had been delivered."

"Won't you tell me something about your job?" Pat asked. "Wasn't it exciting?"

The colonel smiled at his naïve inquiry.

"I suppose you'd call it that—if you can call a war exciting. We were on the jump night and day. After the design had been approved and the engine had passed actual running tests satisfactorily, we had to collect the tools and equipment to start manufacture on a big scale. We figured that twenty-two thousand, five hundred engines would be needed by the army and navy.

"No manufacturer had machinery big enough to handle the parts. Every part required nearly three thousand jigs. Skilled men were hard to find, and everybody wanted them.

"But those difficulties were small compared with the changes we had to make after we once started. We had

to change from eight to twelve cylinders. After we had built about three hundred motors, we got word from France that more horsepower was needed. At that time the design called for three hundred and thirty horsepower. We hustled around and stepped it up to three hundred and seventy-five, only to discover that some of the parts like the crankshaft wouldn't stand the extra strain. So we had to redesign them, too.

"Well, we got under way again and had about five hundred more built when we were told to again raise the horsepower. Four hundred horsepower was wanted. We decided to give them even more, and went up to four hundred and forty. All the parts were overstrained. We had to stop again and enlarge and strengthen the connecting rods, bearings, and all the other parts, as well as the crankshaft again. All the jigs had to be rebuilt. Even the metal specifications had to be changed.

"But we couldn't let up for a minute. Everybody helped."

"Gee," said Pat, "the Liberty motor had a wonderful history, hadn't it?"

"It gave good service, too. Do you remember the NC–4 plane that made the first transatlantic flight from the United States? The one flown by the navy?"

Pat nodded his head. He had read of that flight.

"It used Liberty motors. And the four army planes that flew from Long Island to Nome, Alaska, were also powered by them. So you can see that it was a sturdy as well as fast motor for its time."

After Colonel Emmons had gone Pat learned from Mr. Mounts something that interested him. Mr. Mounts informed him that the colonel had been in the navy originally. He was the only officer borrowed from the navy by the army during the World War. His rank of colonel was given him by the army.

CHAPTER TWENTY-FIVE

A CATERPILLAR WITH A WHALE MOUTH

WHEN time came for Pat to return to the airport on his next visit, he had a companion with him. Bob Stettler lived across the street from Pat and was one of his best friends. During the weeks that Pat had been studying airplanes, he told Bob of many of the things he had learned. Bob, too, was interested and asked his parents if he might go with his friend some Saturday morning. He was two years younger than Pat, but he was already reading books about flying.

It was now Pat's turn to act as guide, and he led the way into the airplane factory in order to start his chum at that point.

"After you see how planes are made," he said, "we'll go down to the Operations Office and find out what's doing."

The huge building was strangely quiet, although here and there men were at work. Pat explained that the factory was usually quiet on Saturday, but he felt perfectly at home and took Bob from one department to another, following the airplane step by step. He showed him the sheets of dural; the jigs where the bulk-

heads were assembled; the tall fixtures where the wings were put together.

Near the last-named place they found the superintendent, Mr. Goin. He was conferring with another man over a blueprint. As he turned to go to his office he recognized Pat.

"Well, young fellow, have you seen a plane tested yet?" he asked pleasantly, recalling the former conversation with the boy.

"No, sir, but I've——"

"Keep your eyes open to-day," the superintendent interrupted enigmatically, "and you may see one. And that reminds me. How about the wind tunnel? You've seen that, of course?"

Again the boy shook his head.

"Well, well."

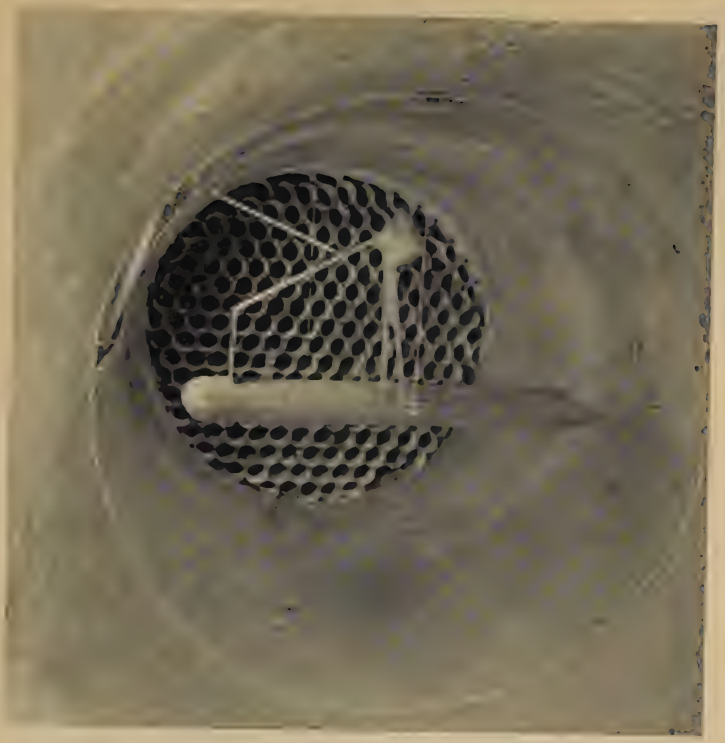
The superintendent turned to his companion.

"Can you spare a minute, Mr. Vary?"

He went on to recount briefly Pat's interest in aviation. The other man at once nodded his head. So Mr. Goin introduced Pat to him.

"Pat, Mr. Vary is willing to take time to show you the wind tunnel which, you know, is the foundation of airplane testing. It has made a science of aeronautics. If you're going to understand this business you'll have to tackle the wind tunnel before long, and the earlier the better."

"I'm not exactly an aeronautical expert," said Mr. Vary, as he led the boys toward a far door opening off



A wing model was suspended on wires upside down

LEFT: The propeller turned one revolution.
RIGHT: Loading with sand to discover the breaking point is a common test in airplane design.

the factory, "but I do know something about the wind tunnel. My job here is to look after the materials that go into our planes. We make any number of tests before we decide what to use. Most factories building airplanes do the same thing."

He opened the door, and they walked into the tunnel room. In the center, running down almost the entire length, was a long, hollow cylindrical object, supported on legs.

"Gee, it looks like a big caterpillar," exclaimed Bob.

"And it's got a mouth like a whale," added Pat.

Smiling, Mr. Vary took a position facing the boys.

"Now," he began, "just to see how much you youngsters know about the business, I'm going to let you tell me what this caterpillar with the whale mouth is used for."

Both boys spoke almost at once.

"To test airplanes," said Bob, while Pat declared, "You put models in it and turn on the wind to see how they act."

"Both right. We can send wind through this tunnel faster than a hurricane—and we use a speed of eighty miles an hour. Boy, how it blows! Can you tell me—either of you—who invented the idea?"

"The Wright brothers," spoke up Pat.

"Yes. It's another thing that aviation owes to them. They were forced to do it after they had wrecked so many large-sized planes that their money was giving out. They had to find a way to experiment more cheaply,

so they rigged up a stovepipe and set an electric fan at one end. Then they suspended their wing models inside and studied the effects of the wind on them. It was one of the factors that finally made it possible for them to fly."

"How are models suspended inside?" asked Bob.

Instead of answering the question directly Mr. Vary led them to a window at one side of the tunnel through which they could look into the interior. It happened that a wing model was inside at the time, and he explained how fine wires served to connect it with instruments which the engineers watched while tests were being made. He showed them a spindle on which the model was suspended, upside down.

"When the Wright brothers began using their stovepipe, they found most of the data on the airplane wing section, or 'airfoil,' as it is called, was wrong. They had to evolve their own. By adding weights they learned how much was required to balance the force of the air stream and bring the airfoil back into its original position. It was then that they determined their famous lift-drag coefficient. Do you understand what that is?"

Both boys shook their heads. Pat had read of it but was not at all sure that he understood about it.

"It is a mathematical term that expresses the ratio of the *lift* of the airfoil or wing surface to what is known as the *drag*. You know, of course, that they are two of the forces contending with an airplane wing in flight: one

seeking to lift it up, and the other to hold it back."

Pat nodded.

"Well, the Wrights discovered the ratio of one to the other. Then they set out to find how to get the greatest lift for the least drag. They constructed an airfoil section which would not only lift itself but something else as well. It was then that the glider became an airplane."

The two boys studied the wind tunnel with renewed interest. The part it had played in making flying possible gave it a new importance.

"Another thing," Mr. Vary continued, "is that wherever the wind tunnel has been improved it has been accompanied by an advance in aviation. The French engineer Gustav Eiffel improved on the wind tunnel of the Wrights, and immediately France took the lead in aircraft. Bleriot, Farman, Nieuport, and the others outdistanced the Americans. After her came England."

He paused a moment, wondering whether he was wearying the boys. But both seemed to be following his words closely. He proceeded:

"During the World War a wind tunnel technique was developed in England by Dr. Stanton and other British physicists. Germany, of course, specialized in tests on lighter-than-air machines. It was the work of Dr. Prandtl in the Göttingen wind tunnels that contributed so much to making Germany the leader of the world in the design and construction of that type of aircraft."

"How about this country?" asked Pat. "We're not behind, are we?"

"I will answer that by asking you if you have ever heard of the Guggenheim Foundation?"

Both boys nodded.

"During 1929 it staged a competition for airplanes which could come up to certain specifications and qualifications based on safe flying. The Curtiss Tanager won, you remember. The wind tunnel played quite a part in the building of that design. The Curtiss people have one of the best engineering laboratories in the entire aviation industry and one of the few commercial air tunnels."

"Won't you please tell us something more about airplane engineering?" asked Pat. "One man told me it was the most important part of aviation. But maybe we're keeping you too long."

"That's all right," Mr. Vary reassured him. "The engineering side of the business is very important. It tells us what materials should be used, in what dimensions they should be fabricated, and how they are to be assembled. Along with all this, it gives us detailed drawings covering the entire operation. The staff knows in advance almost to a T what any particular design of plane will do."

He led the way across the floor to a bench alongside the wall and lifted himself to a seat, while the two boys in turn settled themselves comfortably.

"If we were satisfied with planes as they are now,"

Mr. Vary began, "we wouldn't need to experiment with new designs. But if we are to improve we must carry on the study all the time."

"What's the first thing an engineer does when he begins to design a plane?" asked Pat.

"First of all, he gets his instructions. He finds out what sort of service the plane is going to perform, because each service calls for a certain type. An airplane is like a ship. It can't have everything. He makes up a preliminary weight estimate, figuring what the wings, engine, fuselage, and controls will total. This can be used as a basis for arriving at the wing areas and also the wing curve or airfoil section. He calculates where the center of gravity will be. You understand what that is, don't you?"

Both boys nodded. In their reading and in the construction of model airplanes they had learned how important it is.

"By locating it he is able to locate the wings and landing gear. Its position with relation to the wings, of course, is most important, because if it was only a few inches too far back, or too far forward, the whole ship might not be controllable. And that reminds me of the record made by the Curtiss engineers when they designed one of their large bombers."

"What was the record?" asked Pat.

"The engineers did their work so well that after the first ship had been built it was found that the center of gravity was within three fourths of an inch of the point

they originally estimated. The weight was just eighty-five pounds less than the engineers had figured in advance. This plane weighs more than eleven thousand pounds and has a wing span of over ninety feet. In view of that you can see how scientifically it was designed."

"I'll say so," murmured Bob.

"Well, to go on with our story. After the engineer has gathered all this information and a three-view dimensional layout or drawing of the proposed plane has been made, he resorts to what we call the cut-and-try method. A rough model is made from three to six feet wide and tested here in the wind tunnel. The first form is crude, of course. It is taken out after a time and altered, either by whittling it down or, if it is to be made larger, by adding cement. When the engineers are satisfied with the performance of this crude model they construct a finished experimental model built to scale. From its performance in the tunnel they determine the full-size performance."

"What does that mean?"

"They find out what the power requirements will be and also those of the propeller. And they compute in advance the speed, rate of climb, and many other things about the finished plane."

CHAPTER TWENTY-SIX

THE AIR SCREW

I'VE been finding out about the different jobs in aviation," Pat explained. "You said your job was to look after the materials. What does that cover? Do you buy the stuff that goes into the planes?"

"No, not the actual buying," smiled Mr. Vary, "but I can explain better by telling you something of the problem of aviation materials. You've seen the old Bleriot over in the hangar that looks like it was made of paper and wire?"

Pat nodded.

"They called that 'stick-and-wire' construction. Lately, aviation has brought a lot of development in the uses of materials. For example, aluminum. Twenty-five years ago engineers said that it was an interesting and useful metal but too expensive. They kept experimenting until they learned that by combining it with copper and heat-treating the alloy, they could increase its strength six times without materially increasing its weight. This research into light metals, by the way, is still going on. In fact, that and the combining of metals is just getting well started.

"To-day we know of magnesium, which is one third lighter than aluminum. Then there is beryllium, which

is as light as magnesium and much stronger. It costs about fifty dollars a pound. As the industrial demand grows for new materials they are produced in larger quantities, and the cost is reduced. As the cost becomes less, the use increases, and down goes the cost again. It sounds like a dog chasing his own tail, doesn't it?" he added, with a grin.

"I read that they use wind tunnels for testing automobiles, too," said Bob, who was still thinking about it.

"Yes, that's right. They can be used for automobiles and for airplanes; and then another important use is to test propellers. You can determine their efficiency. And we also test the parasitic resistance of motors in the tunnel."

The look of bewilderment on the boys' faces at the word "parasitic" led him to explain.

"That comes from the word 'parasite.' It merely means the amount which the drag of the motor will impede an airplane in its flight. The shape of the motor has something to do with it. If you were to submerge an airplane in a tank of water and draw it along it would move much easier and faster without the motor. The stream-lined object slides through the air easier than one that is spherical or cylindrical. It was through the use of their stovepipe that the Wrights devised their propeller."

"Did the Wrights invent the propeller?" asked Pat. "I thought it was used on boats long before their first flight."

"Not the airplane propeller," corrected Mr. Vary. "The boat propeller wouldn't answer the same purpose. Neither would the electric fan. Both were inefficient from the flying standpoint. The airplane propeller which they developed had blades that were cambered just as scientifically as the plane's wings. Next time you get a chance, look closely at one and you'll see how its design has been revolutionized. As a result of the Wrights' work, boat engineers and others have come to study the airplane propeller in order to perfect their own types."

He jumped down lightly from the bench.

"Well, boys, this is some lecture I've given you, and now I'll have to get back on my own job. If you want to learn something about propellers go over to the hangar and ask for Jerry. He's one of the mechanics and an expert on the subject."

"Oh, I know Jerry," Pat exclaimed. "Thank you very much."

After parting from their guide Pat took Bob across the factory to the door nearest the hangar and ushered him into the latter building. It did not take them long to find the mechanic. He shook hands gravely with Pat and then with Bob and listened politely to their request.

"So Mr. Vary said I was an expert, did he?" Jerry smiled. "I'll help you all I can, but there's lots about props I don't know. I don't mind admitting it."

"One of the men in the factory told me, when I was watching them assemble a plane, that the prop is made

of forged dural," said Pat. "But on it it said, 'Standard Steel.'"

"That's just the name of the manufacturer. Dural, you know, is much lighter than steel. But wood is the material most commonly used. Another material much used is micarta, made of a special composition."

Near by stood one of the trimotored ships and Pat pointed to one of its shining "props."

"It's about ten feet long, isn't it, Jerry?"

"That's a good guess, lad. It's just ten feet from tip, to tip."

"How fast does it go around? The same as the motor?"

"Yes, at the hub. But not on the outside. When the motor is turning up eighteen hundred R. P. M., those tips are making about nine miles a minute."

"Gee, that's fast!" exclaimed both boys.

"A propeller is nothing but a big screw. The British call it an 'air screw,' which is really what it is. It screws its way through the air."

"That's why the blades are twisted, isn't it?"

"Yes. It forms what's called a 'perfect helix.' Its path is like a spiral stairway. Do you know what its 'pitch' is?"

Neither boy did, so he explained:

"It's the theoretical number of feet a prop will travel through the air in one revolution—one turn of the screw. When I studied to become a mechanic I found a description of the prop's work that I've never forgotten. The prop was described as the means through

which the rotary motion of the engine's crankshaft is converted into the horizontal movement of the airplane. You may not get that at first, but when you do you'll never forget it, either."

"But how does it do that?" asked Bob.

"Well, you see how the blades are inclined. They throw the air backward in a stream, and the resistance of the air to that stream causes what we call 'thrust.'"

"The air thrown back is the slipstream, isn't it?"

"Yes. The air tends to slip under the action of the prop. Did you boys ever see how a prop is balanced?"

When they told him they hadn't he took them into the motor repair room which Pat had visited with Mr. Mounts the preceding Saturday. In one corner were two upright stands each just wide enough to support a propeller. One rested on an arbor in either stand.

Jerry pushed lightly on a blade, and the propeller turned one revolution.

"Do you see how perfectly it is balanced?" he asked the boys. "When the prop is going eighteen hundred R. P. M. there is a pull of about forty tons at its center. You can see that a small variation in weight on either blade will make a decided difference in the plane's flight."

On a flat table near at hand he showed them where the blades were fitted securely into place and the facings checked.

"A most intricate job," he concluded. "And now—you kids must run along. I've got a busy morning's work ahead of me, and the day is almost half gone right now."

CHAPTER TWENTY-SEVEN

"GET YOURSELF A PARACHUTE"

BESIDES Mr. Manning and his assistant, a stranger stood in the Operations Office when Pat arrived there with Bob. He was a short, sturdy individual with a round good-natured face and a pronounced Irish brogue.

"Here he is now," said the chief, as Pat walked in. "Pat, I want you to shake hands with Lieutenant Patrick Callahan."

"And a foine lad he is," said Lieutenant Callahan heartily, as he grasped both Pat's hands and held him off to give him a quick sizing up. "A thrue Callahan. Sure he'll make a flyer. What Callahan wouldn't?"

"Where—what—gee whiz!" Pat exclaimed, considerably flustered. "Is your name the same as mine?"

"So they say. But what of it? Tell me, lad, have the wings sprouted yet?"

"Don't you see that little bulge on the back of each shoulder?" grinned Mr. Mounts.

"He can flap them already. Bet you!" cried the lieutenant.

Mr. Manning came to the boy's rescue.

"The lieutenant is here to test a ship for some folks," he told Pat. "When I heard he had come I asked him to

wait around until you could meet him. Are you two cousins or something?"

"Sure. All Callahans are cousins under the skin," the lieutenant answered promptly. "Aren't we, lad?"

Pat nodded uncertainly. Already he felt a warm liking for this flyer with the shining wings on his uniform and his smiling Irish face.

"He's a regular daredevil," added Mr. Mounts to Pat, in a hoarse whisper loud enough to be overheard.

"Don't you believe a word of it," denied the lieutenant in pretended indignation. "He's as gentle as a little lamb, and he wouldn't fly any higher than a grasshopper."

Both the chief and his assistant roared with laughter, and the boys chimed in.

"They don't mean me at all, at all. They might be speakin' of my friend Jimmy Doolittle, but not Patrick Callahan. Is it thrue that you've done all these things I hear about and met all these great men?"

Pat nodded eagerly.

"But I'm glad I've met you, too," he added.

"Spoke loike a thrue Callahan. I'm goin' to give you a thing or two to remember me by so that you'll be even gladder. Eh, Roy?"

He turned swiftly to the Operations Chief.

"When I've got the ship ready I'm comin' after the kid. Keep him here till then, will you?"

He buttoned up his fur-collared overcoat, and at the door spoke a word of assurance to Pat.

"Get yourself a parachute, lad. We're goin' to rockabye baby, and I don't want you shootin' out loike a comet or something."

"Jiminy crickets!" Pat exploded as soon as the door closed. "Does he really mean it? Will I get to do a parachute jump?"

The chief and Mr. Mounts exchanged smiles.

"No, not quite as much as that, but you'll probably bite off the edge of a star or two," said Mr. Mounts. "You don't mind that, do you?"

Young Pat sat down heavily in a convenient chair and loosened his sheepskin.

"How about a parachute?" he asked excitedly.

"Get him one, Bill," said Mr. Manning.

From a locker Mr. Mounts took out a bundle of cloth and harness and brought it into the inner office. The two boys bent over it while he unfolded it, displaying the two straps which the pilot fastened about his thighs, and the shoulder straps which looped about his arms somewhat like a vest.

"This happens to be one of the kind you sit on," he explained. "Here on the left side is the metal ring. When you want to open her up, all you have to do is to yank this ring, and it jerks the rip cord. After that, the chute itself will fly open in less than two seconds."

"What's it made of? Cotton?" asked Bob.

"No, this is Japanese silk. It was especially developed for this sort of work because it has to stand a terrific strain when the chute blows open at high speed."

"Do I have to remember anything except to pull the ring?" asked Pat.

"Well, you want to wait a few seconds after leaving the ship to give yourself time to get free and clear. And when you land try to steer away from wires or tall trees. You can guide yourself by pulling on the ropes on one side or the other."

"Parachutes are older than airplanes, aren't they?" Bob wanted to know.

"Yes, they go back to the days of the balloon jumpers. But they've been used by pilots only about seven or eight years. During the World War they would have saved the lives of at least two hundred of our flyers if we had known how to make them. The army didn't adopt them until early in 1923."

"Why does Lieutenant Callahan want me to wear one?" Pat murmured.

"Now, don't worry, youngster," said Mr. Mounts kindly. "I happen to know what he's planning, and it's only a matter of precaution. You don't have to worry about Pat Callahan. His plane happens to have an open cockpit, and all you'll get will be a nice cold ride."

"What plane is he testing?"

"It's one that's been bought by a club of flyers in Detroit."

"Ge-e-e!"

After a brief silence Bob asked: "How do you test planes?"

"Well, it would take me some time to tell you all of

it," answered Mr. Manning. "In the old days we had three questions to solve: Would the plane get off the ground? Could it be controlled in the air? Would it hold together when it landed? Since we've got past that stage we have a lot more things to find out."

"I heard something about how you do it when I was watching them build planes in the factory," Pat recalled.

"That's what is called 'production testing,' a different thing from performance or engineering testing. We fly every completed plane for five hours, as they told you, no doubt. We must see that it is correctly balanced, that the motors run properly, that the props are adjusted correctly, the instruments functioning accurately, and so on. We adjust the compass, make sure the gas lines are in order and feeding as they should, check the fuel and ignition systems, and in general make an inspection such as an automobile tester would make on a car. The other kind of testing takes much longer and is more arduous."

"You use it for trying out new kinds of planes, don't you?"

"New types. Also when we change our engines or the propeller model. Also, when we change the structure of the ship or anything that will affect its aërodynamics. We even test for changes in loading."

"What do you do with the plane in those tests?"

"What do we do? Oh, we put it through its paces. We want to know its high speed and its speed at landing;

its rate of climb; ceiling; its maneuverability and controllability. If it has any peculiar flying characteristics, we want to know what they are."

"Does that mean you fly it as fast as it will go?"

"Usually that's the first test. We've got a level course three miles long marked off along a railroad track near by. I bring the plane as low as I can so that we can see the markers plainly, and send it over that course as fast as it will go straight and level. The day must be calm so we'll have as little air as possible. You see, we get down to a height of only about seventy-five feet, and if anything should happen we wouldn't have room to use the parachute. It would be just too bad."

Through the window he could see Lieutenant Callahan's plane being warmed up.

"Better borrow some warm clothing, Pat."

Mr. Mounts obligingly went to the lockers once more. A sudden thought came to the boy. He turned to his companion.

"Say, Bob, you don't mind sticking around while I get this flight with the lieutenant, do you?"

"Gee, I almost forgot," returned his friend. "My dad is going to stop here for me at eleven o'clock. He's going to take me to town. What time is it now?"

"Ten forty-five," replied Mr. Manning. "See if you boys can tell me what we mean by the 'saw-tooth' climb."

Neither of them knew.

"Well, it's used in checking the rate of climb. It gets

its name from the fact that a pilot goes up and down until his path resembles the line of teeth of a saw. We take certain levels, such as one thousand to three thousand feet, and climb from one to the other at different rates of speed. What we seek to learn is the best speed at which that particular plane can make altitude or reach its ceiling. It varies on each plane."

"Do you stunt the plane during your test?" asked Pat.

"No, not exactly. We do such things as banking and turning, diving, stalling, and any other maneuver a pilot might be called upon to make in the course of flight with his plane. But—here comes your namesake now."

The two operations men helped Pat fasten on his parachute and showed him again where the ring was when he had the chute on.

"Be sure to buckle on your safety belt," added Mr. Mounts.

"'The time has come, the Walrus said,'" quoted Lieutenant Callahan breezily as he opened the outside door. "We'll see whether this Callahan lad can fly or not. Come along, cousin."

Pat murmured a hasty "So long" to Bob. Somehow the words seemed to stick in his throat.

"Don't get worried, now," counseled the older men. "You're going to have the treat of your young life."

"I'm not worried," Pat stammered. "I'm just—just a little nervous. But I'm sure—I'm going to like it."

But what "it" was to be he couldn't for the life of him guess.

CHAPTER TWENTY-EIGHT

LOOPING THE LOOP

THE ship was an observation biplane with two open cockpits, one behind the other. Pat was hoisted up over the fuselage into his seat, the safety belt was buckled snugly across his lap, and away taxied the plane. It moved so swiftly along the runway that it swept his breath away. They turned at the end of the field, the motor banged like a machine gun, and they shot up from the earth in less time than it takes to tell it. Lieutenant Patrick Callahan was determined to give young Pat Callahan a ride that he would remember, and already Pat was "thrilled to death," as he afterward said.

The wind fanned his face, and its chill seemed to cut with the sharp edge of a razor. At three thousand feet the lieutenant brought the ship into a straight and level position and scooted along over the landscape for some distance before he swung around in a narrow half circle and came rushing back. As they passed over the field Pat caught a glimpse of the little group of watchers below, straining their eyes upward. He knew that Bob was still there, probably fascinated by the sight.

He felt a sudden pressure on the back of his neck. His head had dropped forward, and he straightened it with a slow backward pull as he looked out.

"Gee," he whispered, "the ground's all gone."

All he could see was the gray overcast sky. He was not conscious of any unusual sensation except that he was sailing off somehow into space. The plane kept riding along smoothly as it climbed up the inside of the loop. Now it was nosing over on the top. He was upside down. All around was the gray sky, but so fast did Lieutenant Callahan cross the upper side of the loop that the boy did not realize he was sitting head downward. Like water whirled around the head in a bucket, there was little danger of his falling, even without his safety belt. With it he was doubly protected. Down the far side of the loop glided the ship.

As he saw the houses coming up to meet him, Pat felt that he had been sitting motionless in one position and that the earth had rolled around instead of himself. Later, as he read more about looping the loop, he learned it would be possible to carry a glass of water on his lap, while performing the maneuver, without spilling a drop.

Lieutenant Pat surmised that one loop would be sufficient for his namesake on this first occasion, so he climbed up easily to an elevation of several thousand feet and then turned loose the next stunt. Sailing along on an even keel, he gradually pulled the stick all the way back. Up came the nose, over on one wing they went, and around spun the plane. Pat had watched

tailspins from the ground and thought they would be lots of fun. Things were happening so fast now that he had little time to think about it. The ground was directly in front of him and whirling around and around.

He felt terribly dizzy for a moment, but he conquered the feeling and looked out in time to see the descent change into a long dive which straightened out into level flight. The pilot had stopped the tailspin by neutralizing his controls. By that time they had dropped much closer to the earth.

"Boy!"

The word escaped from between Pat's teeth. He relaxed his hold on the side of the cockpit and drew in a deep breath. Lieutenant Callahan felt that he had given Pat enough stunts for one morning. He banked around and abruptly cut off his motor.

As the roar died away with an angry stutter, Pat looked forward in much excitement at the propeller. Would he have to make a descent, after all, in his parachute? Would that make him eligible to join the Caterpillar Club?

He turned and peered back at Lieutenant Callahan to watch for a signal. But the pilot merely nodded to him with a broad grin of assurance. Smoothly as a bird, the biplane glided downward. It was an old maneuver to the army man, for his instructor had cut off his motor more than once at that height and made him land his ship within a fifty-foot circle of a marker on the field. They leveled off as they neared the surface of the

ground and dropped down in a perfect three-point landing.

"Well, Pat," Mr. Mounts greeted him as he gazed over the side of the fuselage and pinched himself to see if he was actually back on the ground once more, "how does it feel to loop the loop?"

The boy unbuckled his belt and stood up, stretching his stiff muscles.

"Gorg-e-ous," he shouted, not realizing that the motor was no longer roaring in his ears.

The men escorted him into the Operations Office, where he slowly removed the impedimenta, parachute and arctic clothing. His namesake followed him in, still eying him quizzically. He was waiting to see how the maneuvers had affected young Pat. When the lieutenant failed to find any trace of fear or air sickness he clapped Pat lightly on the shoulder.

"You and I will eat lunch together, kid," he announced admiringly. "We'll talk over the battle where nobody can listen in but you and I."

So it was agreed. Not long afterward the two climbed into Mr. Mounts's car, borrowed for the occasion, and drove up to Dearborn.

"Where are your headquarters?" asked Pat, after they had shut themselves inside an eating booth and their orders had been taken.

"Selfridge Field. Ninety-fourth Pursuit Squadron. First Pursuit Group."

"Isn't that the same squadron that used to use the

'Hat in the Ring' for its insignia? Isn't it the one Captain Eddie Rickenbacker commanded during the World War?"

"Thrue, every word of it," replied the lieutenant. "Some day you must come over to the field and visit us. It's a gay place, no foolin'."

Pat's eyes shone.

"I'd love to," he said simply.

After he had taken a few mouthfuls of soup he asked: "Did you say Lieutenant Doolittle is a friend of yours?"

"I believe I did mention his name. He and I have flown at the same field, and I think I can call him my friend. Why do you ask? Know him, kid?"

"No, but I've heard he is the chief test pilot of the army."

"And a most excellent flyer. But you're wrong about the army. He resigned to take command of the aviation activities of a large oil company with headquarters at St. Louis. What a wonderful pilot he is!"

"He must be a grand chap to know."

"Listen, I'll tell you what kind of a chap he is. Did you ever hear about his South American trip? No? Well, he obtained leave from Uncle Sam to travel to Chile in order to demonstrate a certain type of pursuit plane to the Chilean government for the manufacturer. That was in 1926. As luck would have it, he fell twelve feet from a platform to the ground—no, to a concrete pavement—and broke the bones in both his legs. This all happened just before the demonstration was scheduled."

He helped himself to a generous chunk of meat and went on:

"Jimmy was in the hospital when the government asked that the plane be flown. His legs were in plaster casts. What did he do? He had steel braces made, took off the casts, had himself carried to the plane and placed in the pilot's seat so that his feet were on the rudder bars; and somebody kicked over the prop. A grand demonstration was had by all."

"I don't see how he did it."

"Nobody else did, either. But I thought it was even more darin' when he flew over the Andes a little later with his crutches strapped inside the plane. He was the first American to make that flight."

"Won't you tell me some more about him?"

"They had a little verse that somebody made up:

"'Then hats off to Jimmy. Can anyone tell
Where he might have flown had his ankles been well?'"

"I know something about him," Pat added. "He was the first pilot who ever flew an outside loop."

"Yep. He flew downward instead of upward and then climbed around on the outside. Few pilots have ever done that stunt even to this day. But you mustn't think Jimmy Doolittle is all stunt, Pat. He holds the degree of Doctor of Science from Massachusetts Institute of Technology for his work in aërodynamics."

While the dessert was being brought in Lieutenant

Callahan told Pat another interesting story about his friend.

"One day at McCook Field a wager was made that Jimmy and another pilot, Alex Pearson, could take off, fly, and land without breaking a twenty-five foot cord fastened to their two planes and holding them together. A lot of bets were made on both sides. Well, lad, the two pilots went through the maneuvers perfectly and actually flew for some fifteen minutes, thus tied together. Just like two trained hawks."

It was in 1925, Pat learned, that Lieutenant Doolittle won the Schneider Cup Race, the international seaplane event. He broke the world's speed record for seaplanes, although himself an army flyer; and hence came his nickname of 'Admiral.'

Pat was sorry to part with his new friend and "cousin," and after they returned to the Operations Office renewed his promise to visit Selfridge Field some day. After they shook hands the lieutenant took off in his ship, and Pat decided to spend another hour about the airport before going home.

CHAPTER TWENTY-NINE

THE SPOKANE SUNGOD

AS HE entered the hangar Pat spied a group of men gathered about a small biplane which apparently had just arrived. It was, he discovered on approaching more closely, a red Buhl Sesqui model. He had seen several planes of that make before and so recognized it without difficulty.

The young man standing in the center of the group seemed familiar. He was over average height, with dark hair and a Doug Fairbanks mustache, and he smiled winningly. Pat thought surely that he had seen him before. Then he spied the name *Spokane Sungod* on the biplane and realized that this was Lieutenant Nick Mamer, whose pictures he had often seen.

By listening in on the conversation of the group he learned that the noted aviator had just flown in from the West on his way to Marysville, near Port Huron, Michigan, where the Buhl plane is manufactured, and was staying overnight in Detroit.

The boy hovered about the edge of the group, eagerly waiting for the conversation to come to an end. One by one the men drifted off, and finally the lieutenant was

left alone. He lifted a suitcase from the cabin and turned, ready to go. Pat stepped forward.

"May I carry that suitcase for you, Lieutenant Mamer?" he asked politely.

The aviator stopped short. His smile sparkled.

"Thanks, sonny. I guess I can carry it all right."

Pat's face fell.

"Oh, rats. I wanted to talk with you so much. I'm learning to fly and——"

"What's that? Say it again."

Pat repeated his wish. Lieutenant Mamer set down the suitcase.

"What in the world do you want to talk to me about?" he quizzed. "I'll be glad to—— Come into the cabin with me."

Pat's face lost its sadness.

"Why, sir—about your flight in this plane. I read about it in the papers, but I want to talk with you about it. And I would like to know how a plane is refueled in the air."

Lieutenant Mamer laughed.

"The flight is an old story by now. It's past history. But I'll tell you how planes are refueled. Come along."

Pat followed him into the cabin, tingling with expectation.

"What does a boy like you know about my flight?" the pilot queried curiously. "I thought everyone had forgotten it."

"No, sir," Pat declared enthusiastically. "It was too

wonderful. The longest non-stop flight a pilot ever made. Gee!"

"The trouble with these records is that they don't last long. At the time it was the longest non-stop flight —but that was back a whole year ago."

"I read that it was even longer than the longest non-stop made by the *Graf Zeppelin* between Friedrichshafen and Tokyo. That was 6,880 miles and you flew 7,200. What a long trip in an airplane!"

Again the lieutenant laughed amusedly.

"You youngsters make an adventure out of flying," he said. "By the time you are as old as I am you will realize that it's a business."

"I know," replied the boy. "Mr. Mayo called it that, too."

Briefly he explained his desire to fly and how he had been learning, step by step. He mentioned Mr. Stout, Captain Hawks, and the others who had helped him.

"So you're on the sky highway, eh, lad?" remarked the pilot after he had finished. "Well, it's an interesting highway. I ought to know. I've been on it for fourteen years."

"And I'm only fourteen years old."

"It's not so long measured in flying hours. Well, I'll give you an outline of my flight in the *Spokane Sungod*."

Pat folded his hands to indicate that he was all ears.

"We took off at Spokane on Thursday, August 15th. We had to lift a load of thirty-one hundred pounds, and

I took a run of about six hundred yards down the field before we went up. The plane made a beautiful rise, and we were off."

"You flew to California first, didn't you?"

"That's right. Our schedule was all made out, and we had our plans made to end the flight by Sunday night. But you know how the plans of mice and men sometimes get all bungled up."

The boy nodded.

"We made Oakland all right Friday morning and then turned about to head for Wyoming. All went well until we arrived over that state. There our luck broke."

"I know. It was your refueling line."

"It broke twice on us. We had to keep flying until night before we could try again. It was heartbreaking. I don't even like to think of it."

"Anyhow, you kept flying."

"Yes. But I don't mind telling you we were tempted to quit. We lost fifteen hours over Wyoming—fifteen precious hours. For more than eleven hours we had to soar over Rock Springs, waiting to get our gas. We actually made nine refueling contacts. And the weather didn't help any."

Pat nodded sympathetically.

"Well, to make a long story short, we tried twice over Cheyenne and only took on seventy gallons. The air was so thin our refueling plane couldn't take up more than fifty gallons at a time. North Platte, Nebraska, was

two thousand feet lower altitude, and so we finally got there and took on four hundred gallons. That was Saturday night."

"From there on you made good time, didn't you?"

"You bet. Things got brighter. We refueled at Cleveland and again at New York City. Then we turned west again."

"When did you get back to Spokane?"

"Tuesday evening."

"So you flew from Thursday to Tuesday?"

"Yes. We were in the air one hundred and twenty hours. Art Walker was my co-pilot, you know."

"It was the first non-stop round-trip flight across the country, wasn't it?"

"So they say. But you wanted to ask me about refueling. Let's forget the flight for a while and talk about something else. What is it you want to know?"

Pat had absorbed the lieutenant's every word. His youthful enthusiasm was fired by the recital, and he wished he had been present with Mamer and Walker during their battle. The sudden question brought him back with a start.

What was there about refueling that he wanted to know? Everything, he begged.

"Imagine two planes flying in the air," Lieutenant Mamer began, "one of them above and a little ahead of the second one. From the higher to the lower plane extends a hose about fifty feet long. Sometimes a rope or guy line for sliding down lunch baskets, water, oil or

other necessities connects the two. Have you got a picture of them in your mind?"

Pat nodded.

"All right, then. We'll turn the gasoline on and let it flow down to the lower plane until the load has been transferred. Afterward the hose connection can be broken and the ships separate."

"Are planes that refuel much different from regular planes?"

"The body is redesigned and the top of the cabin cut away so that the end of the hose can be secured easily by the lower plane. The hose empties into special fuel tanks carried in the cabin. The fuel is pumped from them by hand into the other tanks in the wings. A removable window is fitted in the place where the top was cut away and gives the pilot greater visibility. It enables him to see directly overhead so he can watch the refueling plane."

"When you fly one plane under another for such a long time, do you have any trouble holding them steady?"

"Well, it takes considerable maneuvering. It's hard on the pilots of both planes. Would you like me to tell you about it?"

"Yes, sir."

"The refueling plane gets ready, loading up with gasoline, in advance of the hour set. When the plane to be refueled arrives over the field it signals its presence by swooping down and then heads for the place

where the contact is to be made. Whenever possible, this takes place over water, because the air there is calmer."

"How does the pilot know where to go?"

"Oh, a note can be dropped. And there is the radio. At any rate, they go to the chosen place, and the plane with the fuel load gets in position two or three hundred feet above the other. The mechanic lets down the hose, and the pilot keeps going straight and level and as slowly as possible.

"It is now the job of the other ship's pilot to come up carefully and connect with the hose. He flies slightly to the left and climbs. When he is about ten feet under the end of it, he has to guard against his own propeller striking it. He speeds up just enough to shoot the nose of his plane past the hose, thus removing the propeller danger; and then pulls her up little by little.

"Meanwhile his co-pilot has opened the window in the top of the cabin and is waiting there. As the end of the hose comes within reach he leans out and grabs it. Then the mechanic up above turns on the stream, and it flows down."

"I read that the best time to refuel is morning or evening."

"Yes. One refueling usually comes at sunset, just before dark. The plane takes on enough gas to last till morning. At sunset the wind dies down and the air is calm."

He rose, indicating that the interview must end soon.

"In refueling you're supposed to have a schedule mapped out in advance before the flight starts," he added. "It calls for a certain number of hook-ups each day, depending on the amount of gas the plane requires."

"Do you think refueling will ever be common? I mean, for all planes?"

"It wouldn't be necessary except on long flights. These early experiments have taught us that it is practical under average weather conditions. That's quite a big thing to know."

"Do you think it will ever be important?"

"Well, on long distance trips it might develop into an important feature. But the most important thing these tests have brought out is the endurance of our planes and motors. Look at the grueling trials they have had to withstand and how well they have come through."

"That's so," said the boy.

"All in all, I would say it has been worth all the effort and expense," the lieutenant concluded, with a smile.

He led the way down from the cabin. In another moment or two he shook hands with Pat, regained his luggage, and strode away toward a waiting bus.

CHAPTER THIRTY

A CALL FROM McDONALD

"PAT. Oh-h-h, Pat!"

By the wood pile in the rear of the Callahan home the boy straightened up. He made a megaphone with his hands and shouted back:

"Yes, Moth-th-th-er-r-r."

"Tel-e-e-e-phone."

"Aw-w-w-right."

Pat picked up an armful of wood and hurried in. The late afternoon sun was still above the horizon, but dusk was not far off. A chill wind whistled around the corner, belying the warm crimson of the western sky. The trees looked very bare and spectral.

"Who's it, Mother?" he called breathlessly as he rushed through the kitchen.

"Your friend, Mr. McDonald."

By that time he was seated at the little stand, the receiver to his ear.

"Oh, hello, Mr. McDonald," he exclaimed.

"Hello, Pat. Did you think I had forgotten you?"

"No—I mean, no, sir. I knew you hadn't."

"How is the flying business coming along? Making any progress?"

"Just fine, Mr. McDonald."

Pat proceeded to detail to his friend all that had happened since the day they had looked up Mr. Mayo and Pat had had his first flight in an airplane. As he related some of the things he had learned Mr. McDonald was frankly surprised and full of praise.

"I'm proud of the way you've gone ahead," he declared. "You've actually done better than you could have done with me helping you. Now, I've got a reward for you."

"Oh, gee!" cried the boy.

"Listen, now. How would you like to make a trip by airplane with me to Cleveland and back again?"

"Honest, Mr. McDonald? Gee, I'd give anything to——"

"All right. It's settled, then. You and I go to Cleveland and back by airplane. I've got to make a quick trip down there and back the same day, and I happened to think you might like to go along."

"How soon will we go, Mr. McDonald? To-morrow?"

The golf club chairman laughed.

"I can't tell you the exact date, but I'll try to fix it for a Saturday. You'll have to be ready to go at quick notice. Ask your folks, and be sure it's O. K. with them."

"Yes, sir. And—thank you, sir."

"That's all right. You know, I'm supposed to help you a little. I don't want you to think I've been neglecting you."

"Oh, I don't. You haven't, Mr. McDonald."

"Good-bye."

As Pat banged down the receiver he leaped gleefully from his chair, upsetting the stand and crashing into the dining table. "Hooray!" he shouted. His mother hurried in to learn the reason for the excitement. "Hooray!" he shouted again, restoring the stand and telephone, and rubbing an elbow that might have been fractured as easily as not, judging by the bump it got.

"Do you have to break up the furniture?" asked his mother, smiling at his enthusiasm.

"Gee, Mother, Mr. McDonald is going to take me to Cleveland in an airplane. Isn't that swell? I can go, can't I?"

His mother, being a wise woman, did not promise too quickly.

"We'll wait and see what your father says," she suggested calmly. "But," she added, as she watched the shadows chasing across his eager face, "I'm sure you can go."

Whereupon he threw his arms around her and printed a loud smack on both cheeks. Then he rushed back outdoors in a fever of industry and attacked the wood pile as it hadn't been attacked all fall. Through the window his mother watched the flying hatchet and the growing kindling.

"Gee!" she said, repeating his favorite expression. She wiped the mist from her eyes. "Isn't it grand to be young?"

CHAPTER THIRTY-ONE

HIGHWAYS OF THE SKY

SATURDAY came at last. Pat had arranged with Mr. McDonald to meet him in the airport passenger terminal at nine-thirty o'clock. He visited the Operations Office for a while with Mr. Dean and left with just time enough to keep the appointment. As it was, he arrived ahead of his friend.

The terminal was a low square structure of white brick and stone. Its roof was flat, the edge being bordered by an esplanade where passengers, while waiting for planes, could enjoy the open air or watch operations on the field. A small wall around the roof served as a parapet, and within it, beyond the passenger walk, rose the second story, in which were housed the general offices of the Stout Air Lines, Inc.

He walked from the boulevard across an open space set aside for automobiles and busses and passed through the entrance. The waiting room reminded him of a miniature depot. A ticket window was located conveniently in the center of one side. A dark wooden railing separated the main part of the waiting room from a passageway that led from the front past the ticket office to the exit door.

Pat found a seat near the fireplace and warmed his hands for a moment. The raw wind had nipped and chilled him during his brief walk. But he was too excited to sit still long. Soon he was on his feet, peering through a rear window toward the loading gate, looking at the enlarged airplane views on the walls, and studying folders which were stacked neatly on a desk, giving the time-tables and routes of many different air lines.

Three persons, two men and a woman, were already in the waiting room when he arrived, and he surmised one of them, at least, was to be a fellow passenger, because of the Gladstone bag resting near by on the floor. In and out of the room, back and forth between ticket office and the offices upstairs, hurried a young man whose smart appearance and air of business did not fail to impress Pat. He was clothed in a uniform of dark blue with military cap to match. Gold braid marked his cuffs and the band of his cap, and the left side of the blouse just below the shoulder bore his title, embroidered in yellow letters: "Flight Escort."

The outer door opened to admit Mr. McDonald. He came in carrying a portfolio and followed by another man who evidently was to accompany him to Cleveland.

"I'm not setting you much of an example for keeping appointments on time," said Mr. McDonald breezily, as he smiled at Pat. "You'll excuse me, won't you?"

"I didn't mind the wait," replied the boy. "I've been looking around."

"Trust a boy to keep interested around a place like

this," said his friend, turning to the stranger. "I'll bet Pat could spend a week here and find something new every minute."

"The boy and I have a date with Stan Knauss," he continued, setting down his portfolio. "His office is upstairs. As soon as I get them started talking, I'll be back."

Mr. McDonald had telephoned Mr. Knauss on the preceding day to make his reservations and had then explained something of Pat's interest in flying and how energetically the boy had been pursuing his hobby. Mr. Knauss had suggested that he would like to see Pat, as he might be able to arrange something of special value on the Cleveland trip. All this was as yet unknown to Pat.

He followed Mr. McDonald up a short flight of steps to the second floor, where Pat found himself at the threshold of a group of busy offices. In one sat a young woman before a telephone exchange board; in another, several young men were working at desks over large record books. He had time to observe this much in one sweeping glance before he followed his guide into an inner sanctum.

"Stan," said Mr. McDonald, "I want you to meet my friend, Pat Calahan. Pat, this is Mr. Knauss. He's the man who directs and manages these air lines, just like the general manager of a railroad."

The boy looked across the desk at Mr. Knauss. A pair of keen blue eyes twinkled at him from behind

round spectacles as the general manager rose from his chair and reached a hand across. Pat was impressed with the thought that the aviation industry is a business of young men. Like Mr. Johnson, Mr. Knauss was in his early thirties and had an enthusiasm for his business that was contagious.

Pat had read that this air line was the first in the country to be organized to handle passengers exclusively on a regular schedule. It had commenced operations in the summer of 1926, and by December, two and one half years later, had transported one hundred thousand passengers, all without a single injury. Much of the credit for this and most of the directing effort, he knew, was due to the young man about whom the organization revolved.

"Say, Stan," said Mr. McDonald, after the hand-shaking had ended, "there's a friend of mine down-stairs who's going to Cleveland with me. Suppose I leave Pat here with you for a little while? Will you answer some of his questions?"

"All I can," promised the general manager with a smile.

As Mr. McDonald retired, the telephone bell rang, and Mr. Knauss took down the receiver. The call was from a customer who wanted to engage a special plane for a swift flight to Toronto.

"Every time the bell rings we have a new situation," commented Mr. Knauss. "Railroad and steamboat men and even bus operators have precedents to guide

them. But we in the air-line business haven't any. Take the method of soliciting traffic, for example."

"What is that?" asked Pat.

His first feeling of embarrassment had disappeared, and already this new branch of the aviation industry sounded interesting.

"Every transportation system tries new ways to increase its business. All solicit traffic. When we do it, we have something different to contend with—a fear in the minds of passengers. No man taking a railroad trip worries about his safety now, although in the early days of both railroads and steamboats the fear of accidents was just as hard to overcome. I've even heard that passengers in those days were warned not to undress at night because of the danger."

Pat could not refrain from smiling.

"The questions about flying that prospective passengers ask us," Mr. Knauss continued, "are like those you or I would ask if we were going to take a ride in a submarine. Flying is so new to most everybody that such questions are only natural."

"Won't you tell me some of them?"

"Oh, they range from, Do I have to wear special clothing? to such inquiries as, How high do you fly?—Will I get sick?—Do your planes start on time?—and so on. Perfectly natural questions. What we are trying to get out of people's minds is that this flying business is a game. Why, do you know—" he broke off abruptly, and paused to emphasize his words—"do you know that

aviation requires absolute application to the job more than any other business? The reason is plain. If we don't give it, we'll go broke. We're still in the pioneering period; the industry is not old and established like so many others. Mistakes in our business are too costly; we can't afford to make them. That's why we have to be on the job *all of the time*."

From their seats in the office they could look out over the landing field. The view was an extensive one and took in the gate near the depot where outgoing planes taxied up to receive passengers, and incoming planes stopped to unload their cargoes. As Pat and Mr. Knauss chatted a plane moved up to load—one of the sightseeing ships that took spectators for a short flight over Detroit.

"We went into the business of aërial tours as a side line," said Mr. Knauss, as they watched the people board the plane. "It came after our cross-country routes had been established. We received many calls from persons who said the trip to Grand Rapids was so far it would make them dizzy and they wished we had a short hop they could take—a sort of sample. Many of them wanted to see what flying was like. Eighty-five per cent of them had never flown before. So we tried out the sightseeing trip, and it has developed into a most profitable end of our business."

The plane outside swept around on the concrete in a perfect circle and slowly taxied toward the runway.

"Besides the aërial tours, we have our taxi service.

Our regular flights to Chicago and Cleveland, of course, are made in transport planes, and in addition we use a Fairchild plane for taxi work. Hopping back and forth."

"How do you mean?" asked Pat.

"Well, sometimes we get a call over the phone from a passenger who had missed the three o'clock plane to Cleveland. He wants to get over there just the same. Or he misses the ship to Chicago. We send him off on the single-motored plane and flag down the big plane at one of our stops, so he can catch up with it. There's still another use for the taxi plane."

"What's that, Mr. Knauss?"

"Ferrying. Frequently we have to move one of our men around. Maybe a pilot in Dearborn is needed in Cleveland, or vice versa. We might be laying out a new route where frequent stops are necessary for checking the landing fields and looking over the territory. It is more economical to do this with a single-motored ship than with a trimotor."

A light tap sounded on the door.

"Come," called the general manager.

A young man stepped in and halted when he saw that his chief was busy.

"Mr. Jury," said Mr. Knauss, "shake hands with Pat Callahan. Pat, this is our general traffic manager. Don't go, Glenn. I've been telling Pat about how to manage an air line."

"I hope you haven't left out the traffic department, sir," said Mr. Jury, with a smile.

"I mentioned it to him, but only briefly. You know, Pat," turning to the boy, "that in soliciting traffic our men have to do more than knock on somebody's door and say: 'Good-morning. We've got some nice fresh airplane rides this morning. Won't you have one?' Our methods have to be original because the industry is new. Methods used by the older transportation systems would not serve us."

"Many of the practices now used in this branch of the business were first inaugurated by this air line," added Mr. Jury. "We were the first, you know, to specialize on handling passengers."

"We had to try out different things for ourselves," said Mr. Knauss, "because we had no guide. We couldn't copy anybody else. Some of our ideas were successful and some were not."

"Won't you tell me about some of the good ones?" asked Pat.

At this juncture Mr. Jury stepped over beside his chief and conferred briefly for a moment. He then excused himself, retiring to his own sanctum, and Mr. Knauss resumed his talk with Pat. He looked thoughtfully at his watch.

"Nine forty-five. Well, we've fifteen minutes yet before your ship leaves, Pat. Let's see. Where were we?"

"You were going to tell me about some of your ideas."

"Right. You will have to go back with me into the early days of the business. There's the question of uni-

forms. One of our pilots would fly with a nice clean shirt, knickers, and sweater; another would wear a wind breaker; another might wear puttees, and so on. Everyone used a different costume. We felt that it might be good psychology on our customers if all our men adopted the same uniform."

"How do you mean?"

"It would help to create the impression of an organization. We didn't want to make circus horses out of our men, but we saw that every sort of transportation system, from railroads to busses, all had regular uniforms for their men. It gave an impression of permanence. In our case it helped the mental attitude of our passengers. If someone wanted to ask a question he knew where to go and whom to ask. The adoption of uniforms by us was widely discussed and served as a guide to other air lines."

"The uniform is a swell one," Pat declared.

"Yes, dark blue and gold go well together. Another idea of ours is that of using a flight escort on each trip. While it hasn't been adopted generally as yet, it is getting lots of attention."

"I saw one of them while I was waiting downstairs."

"It was probably Otis Kline. He's the chief of our flight escorts. When we began to carry passengers each plane took along a flying mechanic as well as its pilot. He could do the necessary mechanical work at each end of the line and besides could act as junior pilot in case of emergency during the flight. Afterward, when we

began to use larger ships and carry more passengers on each trip, we saw a need for something more. Most of the passengers were unfamiliar with air travel. We conceived the idea of taking a man and putting him right in the cabin with them."

Pat leaned forward, much interested in this story of the beginnings of the flight escort idea.

"In all other branches of transportation there was such an employee. On the train it's the conductor. On the steamboat it's the steward. We put a uniformed man in the cabin to answer questions, point out objects of interest along the route, act as an air-line salesman, make passengers feel entirely at home and attend to their wants. We started with one escort; now we have seven."

He pressed a buzzer signal on his desk and looked once more at his watch.

"Ten minutes yet. Besides the flight escorts, we have several other departments. The chief pilot directs the operations; the chief mechanic has charge of the repairs."

"I bet the chief pilot's job is a busy one, isn't it?"

"Right. I'll let you talk with him, and he can tell you something about it himself. He makes out a schedule, for one thing, covering the week's operations in advance and assigning each pilot to his trips."

Mr. Knauss summoned one of the young men from the outer office, Mr. Rogers, who had charge of the accounting and auditing department.

"I want you to meet these men, Pat," he explained, "so that you will have a clearer idea of what is involved in managing an air line. In Mr. Rogers' department we make up our chart of daily air-line revenue and traffic operations as compiled from the reports of the pilots and the flight escorts. We have a summary of the ticket audits as well as our general bookkeeping accounts. We keep comparative statistics so that at the end of every month we can see how we compare with the previous one and also with the same month of the previous year."

While Pat was looking at the big charts which Mr. Rogers spread before him Mr. Knauss again pressed his buzzer, and almost instantly the door opened and in came the flight escort whom Pat had seen in the waiting room.

"Otis, this is Pat Callahan," said Mr. Knauss. Then, turning to Pat, "Otis, as I told you, is chief of our flight escorts. He can tell you about his work. By the way, Pat—" Mr. Knauss stopped and peered through his glasses straight into Pat's eyes—"how would you like to be a flight escort yourself for a day?"

A wave of red flooded over Pat's face as he heard the offer. He could hardly believe his own ears.

"Gee—oh, gosh—jiminy crickets, Mr. Knauss——"

"That's all right, Pat. I know just how you feel."

He turned to Otis Kline.

"Pat is going to Cleveland to-day with one of the men downstairs—Mr. McDonald. Mac is a friend of

mine and asked me to tell Pat something about an air line. He has shown so much interest that I'm going to let him have the experience of a flight escort. How long would it take you to fit him out in a uniform?"

The chief of the flight escorts looked Pat over critically.

"Not long, sir. Ed Welch isn't down to-day, and his uniform will just about fit Pat."

The general manager shows Pat how the chief pilot keeps track of the airliners

VISITING WITH THE
STOUT AIR LINES PILOTS

Chief Pilot Reed is third from right. Others are (left to right) W. E. (Slim) Larned, Byron S. Warner, Leon D. Sherrick, Sam J. Taylor, James O. Johnson, Lee R. Murphy, Leland C. Brown and J. L. (Monty) Brandon.

"From then on until everybody was aboard, I was a busy guy."

CHAPTER THIRTY-TWO

PAT CALLAHAN, FLIGHT ESCORT

(By Himself)

BEING a flight escort on an airplane is my idea of the finest job in the world. Dad tells me that when he was a boy he wanted to work in a circus, and his second choice was conductor on a railroad train, but I can't think of anything that would suit me better than being an escort.

So, when Mr. Knauss arranged for me to handle the job for a whole day on the ship flying between Detroit and Cleveland, I was tickled pink. It was the greatest experience I could hope to get, and I was tremendously excited, although Lester Doan, who kept me company, told me afterward that I acted like a veteran.

Lester is a real flight escort and a swell guy. He took hold of me as soon as Mr. Kline—that's the chief flight escort—brought me down from Mr. Knauss' office, and told me what I had to do and how to act. We had a hard time finding a cap that would fit me, because I am several years younger than the regular flight escorts, although big for my age. Lester poked in several lockers, and at last he took one of the caps and padded the lining

with paper so it would keep from sliding down over my forehead. It wasn't so hard to fit the rest of the uniform, because, as I said before, I am big for my age.

There was only just time for me to get outfitted before we heard Mr. Kline calling in the waiting room: "Cleveland plane now leaving!"

Believe me, we had to hustle some. First we carried out the bags and luggage of the passengers and stowed them away in the baggage compartment. Lester picked up a bundle of newspapers that were to be distributed to the passengers after we started and told me to stand by the door, ready to help the passengers into the cabin. I got in place just as the first man came up. From then on until everybody was aboard I was a busy guy.

Later, I learned that these planes leave right on the minute, just like a fast express train. After everybody was loaded I climbed in, and the mechanic closed the door behind me. Somebody gave the high ball to the pilot. I could see him turn his eyes from the terminal and move the controls. We began to roll along. At the corner of the runway near the depot he pulled up for a moment and ran each motor separately. Then we slid along the concrete to the far end of the field and wheeled into the wind. Away we went.

Lester let me watch the sights until Dearborn was far in the rear. I could see the twin lakes in front of Mr. Mayo's office, the boulevard, the different school buildings and churches. I thought I could see our house. But it wasn't long before everything below changed

and I couldn't recognize anything. So I turned my attention to my job.

"A flight escort should see that his passengers are comfortable," Lester told me. "Here's magazines for those who don't want to read the morning paper. Go up the aisle and see if anybody wants one."

I had never before tried to walk slowly through the cabin of a big trimotored plane when it was flying. When I was up with Mr. Kuenzel, taking pictures, I sort of scooted back and forth without paying much attention. But now, when I rose to pass out the magazines, I felt somewhat like one would if one was walking on a moving train or boat. But even though the air-speed indicator said we were making 110 miles an hour, there wasn't any sensation of speed.

One man took a magazine. The others preferred to watch out the windows. By the time I got back to my place beside Lester, we were passing our first landmark, Flat Rock. Lester told the passengers its name and also that Lake Erie was visible on our left. It looked a lot different from the way I saw it from a boat. It was smooth and glassy, and the dark clouds gave it a dark, wintry appearance. We crossed the edge far enough out to see an island that stuck up from the surface like a dot.

"Toledo is on the right," Lester announced.

I could see the buildings and business blocks spread out as far as my eye could reach. The altimeter said we were up 2,000 feet.

"About this time we listen to the weather report on the radio," Lester told me. "That's your job, so put on the head phones."

As soon as they were clamped on I heard an announcer broadcasting. Weather prospects for the day seemed fair, and there was nothing to worry about. I told Lester, and he passed the word up to the pilot.

In the distance I could see another plane heading toward us. It was a trimotored ship, just like our own, and when it came closer I could see the ring on the fuselage and the name: "Stout Air Lines." Believe me, it was just tearing along, although our own plane seemed to be standing still. We passed close enough to make out the outlines of the passengers in the cabin windows, but in less time than it takes to tell it the plane had gone by and was rapidly disappearing from view.

The next big event was when we passed over Sandusky, Ohio. Lester made me tell its name to the passengers, so I stood up, cleared my throat, and told them that that was Sandusky. It was a good-sized town, and I took a good look at it, since I had never seen it before. The people seemed very tiny far below. When I looked down again we were over Lake Erie. The wind was whipping up the whitecaps, and I was glad to be up there in the plane instead of down there rocking on those big waves.

I never dreamed riding in a plane on a long trip was so comfortable. In fact, it was so motionless that it almost got monotonous. Beyond Sandusky we ran into a

rainstorm. We could see it ahead of us and moved along straight into it. One moment we were riding in the sunshine; next we were in a dark cloud, and drops were beating against the windows of the plane. Lester turned on the lights in the cabin, and we were just as cosy as could be.

Then we saw Cleveland. What a grand sight it is to look down on a big city from the air. You get a different idea of it from the one the geography gives you. You get a picture of the way it really is. In the case of Cleveland, it was especially good, because you could see the lake shore and the long streets leading away from downtown. We seemed to strike more bumps just outside Cleveland than anywhere else during the entire trip.

Lester told me that we came into the field on the radio beacon and that we had taken the extra time to circle Cleveland because we were a few minutes early. We landed O. K. and soon I was getting my first peek at the Cleveland municipal airport. I have read so much about this place that I was anxious to find out for myself just what it contained. Believe me, the number of hangars was a surprise. There were twelve altogether. One is used for training purposes, and another by the Stout Air Lines for housing their planes at that end of the line, making repairs and so on.

As soon as we landed we went to the Stout hangar, and I saw the office where passengers register for their trips. With me was our pilot, Ralph Reed, the chief

pilot of the air lines and in charge of all operations. Lester joined us, as did John Halpin, the Cleveland manager, and one of their pilots who is stationed in that city.

After we were seated around the table someone told Mr. Halpin that I was learning about the aviation business.

"You mustn't believe anything these fellows tell you," he said, nodding at Mr. Reed and Lester. "If you want to know anything about flying just ask me."

Everybody laughed at that and at several other remarks he made during the meal. He seemed like quite a witty fellow. For instance, we got to talking about blind flying, which means flying without being able to see out of the cockpit, and after we finished, he turned solemnly to me and said: "One of these days, Pat, I'm going to take up a collection for these poor blind flyers."

He was only kidding us, I know, because the blind flyers don't need any help. They're not really blind.

"I don't see why we can't get lights strong enough to break through the fog," said the strange pilot.

"You seem to forget," Mr. Halpin replied, "that the greatest light in the world can't break through it now."

"What's that?" I asked, without thinking.

"The sun," he said, and I couldn't help smiling.

"Tell Pat about the test made by Lieutenant Doolittle," he went on, turning to Mr. Reed.

"Would you like to hear about it?" the chief pilot asked me.

"I'll say. I like Lieutenant Doolittle."

"Well, it took place at Mitchel Field. He demonstrated, as the Guggenheim people said, the practicability of flying blind from one airport to another, provided the airport is properly prepared and the airplane equipped with the necessary instruments.

"In plain language, what Lieutenant Doolittle did was to bury himself in his cockpit so he couldn't see out, take off over wires and water towers, fly away from the field, turn around and fly back across it, turn around and come back again and make a perfect landing. He was in the air for fifteen minutes in conditions that simulated a dense night fog. He couldn't see a thing except the instruments on his board."

"Wasn't it dangerous?" exclaimed somebody. Maybe it was me.

"Hardly. His safety was insured by the presence of another pilot, Lieutenant Kelsey, who sat in the forward cockpit and acted as a safety pilot. He could see everything and would have taken the controls at once if the blind flyer made a mistake. But Jimmy Doolittle doesn't make mistakes."

"What kind of instruments did he use?"

"Mostly standard instruments. He had three which are not now standard equipment on planes; and two of these three will replace instruments we are now using, so only one new one will be required. He had what we call a sensitized barometric altimeter, an artificial horizon, a directional gyroscope, and a visual radio

beacon indicator. You know about the radio beacon, of course?"

I nodded.

"Well, the visual indicator merely means than an instrument has been perfected so that the pilot, instead of listening to the dash and dot through head phones, can watch his course in an instrument. Sometimes the motor makes so much noise he can't hear the beacon. By looking in the glass he knows whether he is right or not. It was developed by a chap named F. W. Dunmore in the United States Bureau of Standards.

"The sensitized altimeter was sensitive to changes in altitude of only ten feet. His artificial horizon told him the longitudinal and lateral attitude of his plane toward the ground at all times while he was flying. His instrument board was so arranged that the hands of all indicators affected by fore and aft inclinations formed a horizontal line when the plane was horizontal; and all directional indicators formed a straight vertical line when it was level and flying straight. That helped him a lot."

Of course, you understand, I didn't remember all this. But I remembered part of it, and I got Mr. Reed to go over my notes afterward and change them wherever I had forgotten something or had a word spelled wrong.

Mr. Halpin said: "The altimeter was just an improvement on the one every plane uses now, wasn't it?"

"Yes," Mr. Reed answered, "but it was far from perfect. Some day we will have an altimeter that will tell

us our height in the air by using the echo quality in sound. Already the research men have isolated a sound made by an airplane while flying and are measuring the length of time it takes for the echo of that sound to return to the plane from the earth. Such an instrument may enable us to measure our height much more accurately."

After lunch was over we tried to find Major Berry, the manager of the airport, for I remembered meeting him at Dearborn with the other men from Cleveland when they visited Mr. Stout. But he was downtown and didn't get back before we had to leave on our return trip.

We had thirteen passengers coming back, but the number wasn't at all unlucky; and besides, there was an extra pilot who was going to Dearborn with us and who rode in the cockpit with Mr. Reed. Nothing new happened, except that the sun shone brightly all the way and the trip was simply wonderful. As we neared home, Lester showed me how to make out the Flight Escort's report, giving the number of passengers on each trip and the other details that are used by Mr. Rogers in keeping his records. After we reached the terminal I had a nice long talk with Mr. Reed and met a lot of the pilots. I got home about five o'clock.

CHAPTER THIRTY-THREE

GROUND FLYING

ON THEIR return from Cleveland Pat accompanied Chief Pilot Reed into the latter's office on the first floor of the terminal depot.

"I'll be glad to help you with your notes," said Mr. Reed, in response to the boy's request. "Also to tell you something of the joys and sorrows of flying. But you may have to wait a few minutes while I talk to some of the pilots."

As Mr. Reed predicted, three of the flyers were waiting for him. Two were to take out the late afternoon planes to Cleveland and Chicago, while the third was on aërial tour work. The two transport men were examining the weather reports that had come in during the day and were charted on Mr. Reed's desk.

"Hello, Chief," said one of them, whom the others called Larned, "I think Lee wants one of us to go along with him this afternoon to show him the way, on account of the weather."

Lee, who was to fly the Chicago plane, grinned.

"I'm going to check this report," he replied. "I think it's hay-wire."

"Have you got your upper air?" asked the chief, examining the reports.

"We passed six storms between Chicago and here on our way over," Lee told him. "No sooner did we get past one than we could see another ahead. We went around all but one."

The chief helped himself to a cigar from a half-filled box lying open on his desk.

"These are from Bert Stoll, one of our organization," he explained to Pat. "Bert's getting married to-day in Cleveland."

Larned was looking over his mail, which he had extracted from one of a row of pigeonholes, each of which bore a pilot's name. He unfolded and spread out a lurid advertising circular describing the merits of a new plane.

"Ha! This ship flies two hundred miles an hour—maybe," he announced, in mock seriousness.

"That means downhill," Sherrick, the third pilot, told him, "and with a whale of a tail wind."

Larned continued, pretending to read from the folder:

"Suppose your employer wanted you to fly a Whoosis plane. What would you do?"

"I've got a good idea for an ad," suggested Lee. "Powder your nose and eat your breakfast before you come down to fly. You look more contented. Fly with Contented Pilots."

At each sally, Pat smiled. He thoroughly enjoyed this camaraderie among the flyers and drank in every word.

"I had to make an emergency landing at Warren," said Larned, "and as usual the wind was blowing straight across the only runway on the field."

"I've never yet seen the wind blow down a runway where the field has only one," answered Lee.

"What most fields need is a runway stretcher," commented Mr. Reed, with a smile.

"Or a wind changer," added Larned.

"Chief, can you have them pull the left motor on Number Ten?" asked Sherrick. "I think it needs it."

Mr. Reed nodded and made a note on his desk pad. Shortly afterward, in response to an unspoken signal from him, the men drifted out and left him alone with the boy.

"When I first began to fly," said the chief pilot, "we made up our own weather report. I was on a mail plane then, flying between Chicago and St. Louis, and we used to go out of the hangar and look at the water tank down the field. If we could see it we made our trip. Another sign was when we passed the ship coming from the opposite direction. We figured if he could get through that far, we could make it, too."

"Weather reports are a big help, aren't they?"

"They are vital. When I first started flying, a good pilot went straight through the weather. He set his course and plowed through. Now he can get around the storms and still arrive on time with his ship."

"Does a pilot have to know much about arithmetic?"

asked Pat. "It's the only study I have in school that is hard for me, and I don't care, unless it is needed by a pilot."

"Let me tell you something about that, Pat. A transport pilot must know not only arithmetic but also higher mathematics. It's not uncommon for one of our men while flying to take out a slide rule and work with it, especially when he is flying against the wind. It helps him determine his ground speed. Then he will go up to a different altitude and check again. A pilot's job to-day is more like that of an engineer."

"How much education does a boy need to be a pilot?"

"I'll answer that question this way. Our transport planes cost a hundred dollars an hour to operate. Our pilots are not judged alone by the way they handle the ships. A pilot who can save ten minutes on a trip is valuable, and he can do it by strict attention to navigation."

He pointed to the trip schedule chart on the wall.

"Our ships make ten trips each day except Sunday. The pilot has to watch three motors that cost eight thousand dollars apiece. He is responsible for fifty thousand dollars worth of equipment. A poor navigator can cost the company three times his salary flying across the country on ordinary trips. So you can see that a transport pilot needs to know a few things. In fact, he needs to know a lot of things.

"Briefly, his first duty is to consider the safety of

his passengers. Their comfort is his second. He can contribute to their comfort by keeping the ship as level as possible. Often he can do that by changing his altitude to smoother air."

"A pilot told me the hardest thing to learn about flying," said Pat, "is landing."

"Yes, that's my opinion, too. He must be trained to make an emergency landing where there isn't any landing field. When the engine cuts out the pilot has just so many seconds before he will be on the ground. He has to pick his landing place and start for it. He can't change his mind once or twice. He selects his field, and then his job is to maneuver to get into it."

"All your repairing is done by mechanics now, isn't it?"

"Yes. But in the old barnstorming day we all did it. I can recall cutting a barbed-wire fence to replace a drift wire."

"What was your most thrilling adventure, Mr. Reed?"

Again the chief pilot laughed.

"Nowadays a pilot doesn't have time to think of thrills. But when I was barnstorming with an old Jenny we had plenty of them. I can remember when we made the first change from an automobile to a plane. That was in 1919 at San Diego. Clyde Pangborn was with me then."

"Gee, that must have been exciting."

"For real genuine excitement, we found plenty when

we started the stunt of changing from one plane to another. We did that for the motion-picture people. I would take up a 'wing walker,' and he would go out on the end of the wing to drop down to a plane underneath."

"I wish you would tell me about it, Mr. Reed."

"I might tell you about one flight that I will never forget. We were up with a 'wing walker,' and he was out on the end of the wing, ready to drop. The plane carrying the photographers got right in front of me, and we caught the wash from its propeller. I had to pull up sharply into a steep climb, and as a result went into a tailspin. The worst of it was that I couldn't come out of it because my man was out on the wing's end. He hung on all right, but his weight prevented me from straightening out. We kept going around and around.

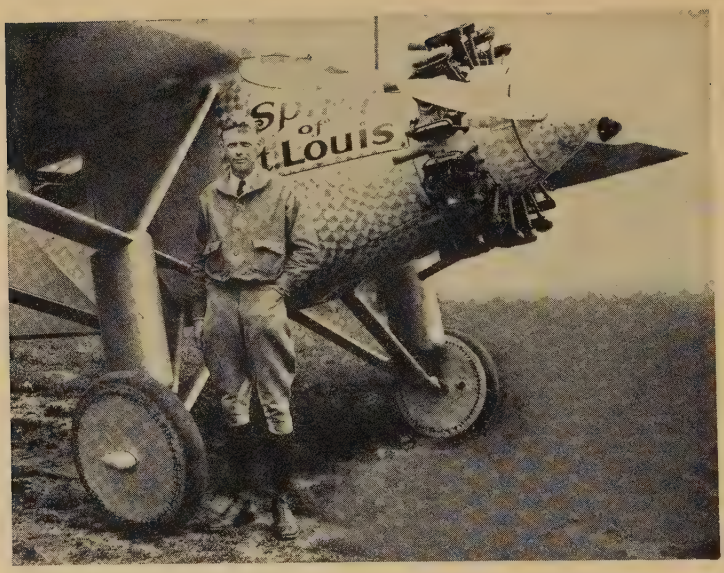
"We had about three thousand feet, and I could see that we were going to have a bad crash. At length I yelled to him that I couldn't pull her out unless he came back to the cockpit. He managed somehow to crawl in, slowly, and we leveled out just in time."

As Mr. Reed paused Pat murmured: "Gee-e-e!"

"But you mustn't get the idea that a pilot's life is an exciting one," the chief pilot went on. "Flying in these days is a regular business. Part of my job is to keep track of things. We make a record of our forced landings and the cause, so that we can prevent some of them in the future. We want to know when a plane is late in

starting and what the reason is. One thing we watch closely is the mechanical operation of each ship. Only in that way can we do our part in improving this great, growing industry. And now," he concluded, "we've had enough ground flying. Let's look at those notes you wanted me to check over."

Pat and Major Royce inspect a pursuit plane



Charles A. Lindbergh and the Spirit of St. Louis

CHAPTER THIRTY-FOUR

THE MAYFLOWER

"PAT, can you get excused from your classes for a few hours?"

The voice was that of Mr. Mounts, calling from the airport. A much excited boy hung over the receiver in the school office.

"Yes—I mean, yes, sir, Mr. Mounts. I'll come right away."

"Wait, Pat. Don't you want to hear what this is all about?"

"Oh, no, Mr. Mounts—er—what is it? Has some flyer——"

The man laughed heartily at his end of the line.

"Not a flyer—but a real dirigible. Wouldn't you like to ride in one?"

"Gee—Christmas! Honest, Mr. Mounts—is there one at the airport?"

"Yes, Pat. It came in about half an hour ago. Kari Fickes, the pilot, happens to be an old friend of mine, and when I told him about you and how you wanted to go over to Selfridge Field he offered to take you himself. Now, how's that?"

"I'll be right down, Mr. Mounts. Don't let him go till I get there. Please!"

The boy hung up the receiver and dashed out of the office. On the way he collided with the principal, knocking a book from his hand.

"Excuse me, Mr. Hood," he begged, as he raced down the hall.

At the corner of the boulevard he flagged a ride from a good-natured truck driver, who dropped him at the airport gate. The day was sharply cold, for winter had finally set in, and soon the ground would be blanketed in white. Now it was slushy and unpleasant underfoot, even on the pavement. Across the field the boy could see the gray-silver of the cocoon-like blimp as it floated lazily above the runway.

Mr. Mounts met him at the entrance to the Operations Office.

"You made good time getting down here," he smiled, "even better than I expected. Come along, and I'll see you on board."

By the time they reached the side of the dirigible its motors had been warmed up and all was in readiness. Its nose was pointed into the wind and was held down on either side by long ropes, with little knots of men serving as anchors.

Pat could see two groups, each comprising three or four men, and in addition he noticed smaller ropes or lines extending down from the breast of the cigar-shaped bag, which were held by one or two men. The

ground officer stood at what might be termed the apex of the ground crew. The door of the car was open, and a short ladder of steps led down to the runway.

"Take a look at the controls before you go aboard," suggested the assistant operations chief.

The boy halted and stared up at the pointed end where an American flag fluttered in the wind. He saw fin-like surfaces that seemed to bisect each other across the tail. Up and down projected the vertical stabilizers as on an airplane; and on each of the two was attached a rudder surface. At right angles to these were the horizontal stabilizers, with the flippers or elevators connected at the far edge. These, also, resembled those of an airplane. Twin motors were mounted on outriggers, one on either side of the car, and faced the rear.

Pat pointed to two round sections of shining pipe which seemed to hug the belly of the ship just back of the propellers.

"What queer-looking things," he remarked. "I never saw anything like them on an airplane. Do you know what they are?"

"Those are air scoops," said Mr. Mounts. "They can be raised or lowered as needed. Do you see how the open end can be brought down to a point just behind the props? That is so the props can force an air stream through them into the bag whenever the helium gas contracts on account of cold weather. You know that any gas expands with heat and contracts with cold. To allow for that a smaller bag filled with air is placed

inside the airship. It is called a 'ballonet.' Air is much cheaper than helium, of course. Whenever the gas expands, air is released from the ballonet to even things up. Similarly, when the helium contracts, as it does in weather like this, instead of taking on more, those scoops are opened, and a stream of air is driven in by the props. But that's enough for now."

He saw that already the main handling lines had been hauled inside the car, and the ground crew was steadying the ship by its handrail along the car's bottom. They looked expectantly at Pat.

"Better hustle along, son. The pilot's ready for you, and these men here want to get back to their work."

At the ladder Mr. Mounts leaned forward and poked his head inside the car.

"So long, Karl," he called. "Take good care of my boy friend. Here he is."

He boosted Pat up the steps, and the boy walked forward to meet Mr. Fickes.

"Hello, Pat," the pilot greeted him, "sit down here in the relief pilot's seat, and I'll give them the signal."

The door closed with a snap, at once shutting out most of the noise of the engines. The floor of the car moved ever so gently from one side to the other in a faintly perceptible rocking motion.

"All ready, Pat?"

The boy nodded in his seat before the broad celluloid window. He couldn't trust himself to speak. What a cosy cabin, he thought, as he looked about. Between

his chair and that of Mr. Fickes was a narrow passage that led to the passenger compartment and to the divan which filled the rear of the car and gave room for three additional passengers. The interior walls were of paneled wood highly polished, and the comfortable seats were generously upholstered.

The entire front of the car directly before his seat was made of special non-inflammable celluloid. The panes were set in tall vertical frames which held them securely and yet did not obscure the vision.

Mr. Fickes slowly raised his hands above his head. Outside, the ground officer gave a sharp command. Pat held rigidly to the arms of his chair and watched the crew. Suddenly they let go. The car rose with a swift bound, as if glad to be free, and then glided forward.

Pat turned in his seat for one last wave to Mr. Mounts who was already growing smaller and seemed to be gradually receding. With nose pointed upward they were being driven toward a higher altitude by the steady motors. How was the pilot controlling the ship? And what an interesting control board!

In the space between the two seats a wheel was mounted, and Pat now saw that Mr. Fickes operated this with his right hand. He had pulled it toward the rear of the ship and kept it there as they ascended.

"It controls the elevators," he explained when he saw Pat watching it. "When I turn it forward I depress the elevators, and we go down."

"How do you steer the ship, Mr. Fickes?"

"Look."

The pilot pointed to his feet, and Pat saw that they rested on pedals.

"The same as an airplane," the boy explained, while Mr. Fickes nodded.

"You don't have to bank when you turn, do you?"

"No."

The question impressed the pilot with Pat's familiarity with flying, and he saw that the boy was not a mere beginner. He leaned forward and explained the controls.

About that time they reached their altitude, and the forward speed increased as soon as they ceased climbing. Pat had expected to feel considerable vibration once they were moving along at a fast clip, and when he found almost none, he was much surprised.

"How long is this dirigible?" he asked. "More'n a hundred feet, isn't it?"

"One hundred and twenty-eight feet. Its diameter across the middle is thirty-seven feet."

"Gee!" exclaimed the boy, "it must hold a lot of gas, doesn't it?"

"Eighty-six thousand cubic feet. That's its gas volume. Of course, it holds both helium and air."

Pat nodded as he recalled Mr. Mounts's remarks about the ballonet.

"Is this a zeppelin?" he asked suddenly.

"Yes. That is, it is made by the Goodyear-Zeppelin Corporation, which is right now making the world's largest airship for our navy at Akron, Ohio."

"Larger even than the *Graf Zeppelin*?"

"Yes, sir. Look. We're over Detroit already. There's the Lindbergh beacon on the tower of the Penobscot Building."

"And there's the Ambassador Bridge," murmured the boy. "Gee, I feel like a bird up here."

"No bird ever flew like this ship does," answered Mr. Fickes. "But let's go back to the *ZRS-4* and her sister, the *ZRS-5*. Each of them will have a cubical content almost twice that of the *Graf Zeppelin*, and thirty-five per cent larger than the *R-100* and *R-101* of England."

During his remarks he paused from time to time to operate the controls and correct for "air pockets" or bumps.

"This ship, the *Mayflower*, was christened by Mrs. Karl Arnstein," he went on. "Do you know who Arnstein is? No? Well, he was chief engineer of the Luftschiffbau-Zeppelin works at Friedrichshafen, Germany. When he came to this country he brought with him a dozen expert engineers, and they're working now on our zeppelins. The factory at Akron has the world's largest airship plant and dock. It has the largest uninterrupted floor area ever constructed, more than eleven hundred feet long and three hundred feet wide."

The figures impressed the boy. For a time he was silent.

"Is this ship a blimp, Mr. Fickes?" he asked, at length.

The pilot looked curiously at his inquisitor.

"Do you know the origin of that word?"

"No, sir."

"It comes from the word 'limp.' This ship is of non-rigid construction because it has no metal framework, in other words, it's the limp type. During the World War the British called their best limp type the 'B-limp' and that's how the word was born. Yes, this is a blimp."

The boy looked admiringly over the control board hanging above the front windows. He could see the air-speed indicator, drift indicator, altimeter, fore and aft indicator and an R. P. M. indicator for each of the twin motors. Straight in front of him in the center of the window were the indicators that showed the fuel and air pressures, while below them was the compass. The spark and starter controls were on a tiny shelf at the pilot's left.

"Won't you tell me how you control the helium?" he asked.

In answer the pilot showed him an aluminum knob on the instrument board. It was painted red and was marked: "Helium Opening."

"That's it, Pat. If you should pull that out, it would open a valve and let out the gas. But we seldom use it. We've had to valve helium only three times in our history. We don't resort to that operation unless both motors fail and the ship becomes a free balloon. Then we have to let go of some gas, of course, so as to come down."

"How are your controls fixed now, while we're flying?"

"In neutral. When we find our altitude we keep them in that position, except when we correct for uneven air."

While talking they had been flying above the north shore of the Detroit River, and now they were bordering Lake St. Clair. It looked very cold and gray below.

"Have you ever had any exciting experiences flying dirigibles?" asked the boy, hungry for more tales of thrilling adventures in the air. The pilot scratched his helmet and adjusted the wheel to ride over a bump.

"Let me see. Exciting experiences, eh? Well, we do have them once in a long time. They add a little spice to our work. I recall one time when I was flying the *Pilgrim*, out of Akron, with a full load of passengers. The *Pilgrim* is a smaller ship than the *Mayflower* and has only one motor. The engine vibration jarred loose the connection to the fuel tank, and suddenly all my gasoline was dumped out. There I was, up in the air, without motive power and drifting along. Luckily, the wind was not very high. I kept sailing lazily until we came over an open clearing. Then I valved out just a little helium and nosed the ship down. Some farmers were working near by, and they got a big surprise when I dropped out my drag rope and asked them to haul us down."

"Gee," murmured Pat, "how did you get out of it?"

"Fixed the connection to the tank, borrowed some gasoline from one of the farmers, and flew on."

"Just like that," Pat laughed.

"But the most exciting trip was when our chief pilot, Jack Boettner, was flying over Detroit one afternoon and wanted to reach your airport at Dearborn. He had to buck a head wind of fifty to sixty miles an hour. When its speed got over fifty miles it pushed his ship backward, although both motors were going at top speed. The ship was the *Puritan*, a sister of this one. It was tossed up skyward by the wind gusts, but Jack would check the ascent within a few hundred feet, and again he had to check the descent to prevent themselves from being dashed to pieces.

"After an hour's battle he had been forced back two miles. Then the wind slackened, and he drove on to Dearborn, where the ship was tied up for the night. It came through all that bumping unharmed and flew the next day as usual."

Just ahead of them and below, Pat saw the environs of a jewel-like city nestling along the banks of a small river.

"There's Mt. Clemens," said Mr. Fickes. "We'll be over Selfridge Field in two jerks of a lamb's tail."

Pat was sorry to learn that the flight was so nearly over. He fancied he could hear the cries of youngsters who stood below on the streets staring up at the airship as it sailed overhead. All too soon he spied the bend in the winding river, with Selfridge Field close beside.

The pilot turned the wheel toward the front of the ship, and she nosed down. Pat felt the bottom of the

car touch the ground lightly. The door was opened, and a furred head was thrust in.

"Where are you, Pat Callahan?"

"Hello—er—cousin," cried the boy. "Here I am. How'd you know I was coming?"

"Oh, Mr. Mounts called me up and told me. He thought you might need somebody to show you around."

The boy shook hands hurriedly with Mr. Fickes and tried to express his thanks for the ride and his pleasure at having made it.

"It was swell," he declared. "I wish it could have been twice as long." Then to the man at the door: "I'll be right out. Good-bye, Mr. Fickes."

After he had stepped down and walked for a few yards with the lieutenant he turned to take a last look at the dirigible. The pilot had spoken briefly to the ground officer and was now back in his seat at the controls. Pat saw him raise his hands in signal, and the ground officer ordered: "Up ship."

At the command the crew with one accord seemed to heave upward on the handrail. The *Mayflower* was literally tossed a dozen feet into the air. The rhythmic roar of the motors grew steadily louder. Slowly, gracefully as a feather, the airship began to rise. With its nose pointed aloft it moved upward at a slight angle until at last it swung around and scudded away toward the south, for all the world like a homing pigeon.

CHAPTER THIRTY-FIVE

AT SELFRIDGE FIELD

PAT'S gaze swept the field for the first time, and he saw that they were nearing the edge of a wide, level meadow. It was slushy and soaked with a thin layer of water, an aftermath of the recent snow. Straight ahead was a row of long frame buildings somewhat resembling barns, marking the north side. Each bore identification numerals. At Hangar 11-B Lieutenant Callahan paused before a doorway over which were the words: "Operations Office."

"Here, Pat, is where I'm goin' to leave you for the nonce," said he. "We're due to fly in about a minute, so somebody else will have to entertain you until I get back. How'd you like to meet the boss, Major Royce?"

"Major Ralph Royce?" the boy repeated. "Gee, I'd like to meet him."

"Why? Have you heard about him?"

"I'll say. I read every word about the 'Arctic flight' from here to Spokane and back."

"A hard, cold battle, my bhoy. Takin' eighteen pursuit planes and two big transports over a front of thirty-five hundred miles in sub-zero weather was no soft snap, I'm

tellin' you. I ought to know because I was along. At that, not a single plane was lost, which is some feather in the cap of the First Pursuit group, not to mention its C. O."

"One of the newspapers said it was a combat in the front yard of the Arctic Circle against snow, ice, and cold. It measured the endurance of the men and army equipment in the hardest kind of weather."

"Well, then, you know something about Major Royce. Come inside and we'll see how busy he is."

The lieutenant opened the door and ushered Pat into the low-ceilinged office. The place was filled with befurred pilots who were waiting for the moment to fly. They looked like so many rolypoly bears. On one side was a wooden railing separating the main area from a number of smaller rooms given over to weather mapping and meteorological data.

Two of the remaining sides were completely filled with blackboards that were ruled off into columns for operations data. At the far end was a flat-topped desk, and behind this was a door that opened into the administration office. Thither the lieutenant guided Pat through the door to a large desk in a corner where he stopped before a narrow marker. It read: "Major Ralph Royce."

"Gee, this is a regular business office," thought Pat as he glanced around at the desks and listened to the pleasant clatter of typewriters. Soon he heard the lieutenant telling the major something about himself.

Major Royce turned finally to Pat. The latter felt a quick scrutiny which he seemed to pass successfully.

"Leave the boy here," the major directed. "You'll return for him after you finish your flight, Lieutenant?"

"Yes, sir," the lieutenant answered smartly.

After he left, the boy followed his form until it had mingled with the throng in the outer office, most of whom were now putting on parachutes. Straps were pulled around and fastened, the cushiony seats were adjusted, and one by one the pilots filed through the doorway and out onto the field.

A line of fast pursuit planes had been formed facing the hangar, and on each a single propeller was merrily whirling. They were biplanes with open cockpits, which partly accounted for the flyers' thick garb. On the rudders were distinguishing stripes of red, white, and blue, and under the wings were five-pointed stars, symbolic of the Air Corps.

"Watch them for a few moments," suggested the major. "I've got a little bookkeeping to attend to, and afterward we'll talk aviation."

The boy was glad of the opportunity. He had seen planes of the First Pursuit group flying overhead during one of the Dearborn air meets, but this was his first close-up view of military formation. He counted the ships in line and found there were ten.

"To-day's work is designed to instruct the flyers in the duties of flight leader," the major explained. "In military operations an element consists of three planes

flying together, of which one is leader. Two elements make a flight. Each pilot in to-day's lesson will act as leader to two other planes (that is, an element) and will gauge his flying so that his element can follow in proper formation with relation to the rest of the flights in the group."

Pat nodded a trifle uncertainly, for he was not quite sure how each pilot could act as leader of two imaginary flyers. He moved over beside the window to watch proceedings. Most of the pilots were already in the cockpits. Their round faces showed above the edge of the fuselage like so many Eskimos. Lieutenant Callahan turned as he slid into his seat and waved to the boy in the window.

Suddenly, as of one accord the planes wheeled and taxied into position on the field, each one trailing the one ahead like a flock of well trained birds. Together they began to gather speed. They rushed across the slush through flying spray and then left the ground, practically simultaneously. The air was filled with the roar of ten motors blended into one.

During the moments that followed the boy saw one of the prettiest sights that may be witnessed on any air field. The ships flew at sufficient distance apart from each other to allow for the other imaginary "planes," and yet all moved through their maneuvers together, diving, climbing, circling, banking, and finally sweeping in stately formation across the sky like a flock of wild geese and out of sight in the hazy distance.

Major Royce being still busy, Pat wandered into the outer office and studied the blackboards. Two large sections were set aside for "Cross-Country Records" and a third contained a record of "Aircraft Condition." The former were used, he learned, for keeping track of army flyers while away from the field, their whereabouts and the purpose of their flight, as well as its progress.

"We have five squadrons stationed here at present," the major told him when he was able at last to begin their tour. "Three are pursuit squadrons, the 17th, 94th, and 27th. They comprise the First Pursuit group, which is the only one of its kind up to now organized by the army. Two others are planned in the future. The 15th is an observation squadron, serving as the eyes of the ground forces; while the 57th is made up of mechanicians whose job is to keep the ships in the air."

"How many ships are in a pursuit squadron?" asked Pat.

"Eighteen, six flights of two elements each. In other words, there are fifty-four ships in the group, also four army transports."

On their way out they used the passage that led through the Weather Bureau section. Here Pat was at home because of his chat with Mr. Post at the airport. However, he found several things he had not seen elsewhere. One, a large map of the country, was printed on glass and stood in a frame where it could be easily deciphered by waiting pilots. Every morning a meteorological man superimposed the day's weather over this

outline, and the only thing changed from day to day was the latter data.

One side of the section was filled with a blackboard that was entirely covered with weather information sent in by fields east of the Mississippi River, from Mitchel, Langley, and Bolling to Selfridge, Scott, Chanute, and Wright.

"If information from farther west is desired," the major told him, "the pilots can get it after they reach St. Louis. They can stop there and inquire as to conditions beyond. We don't attempt to keep it on our bulletin here."

Outside the Operations Office Pat discovered that the buildings were arranged on both sides of a road which led westerly along the north side of the field. Nearest the field were the hangars; on the opposite side were such buildings as aërial photographic quarters, field headquarters, commissary, guardhouse, and so on, with rows of brick apartments for the officers' quarters in the distance.

Each hangar held something of interest. Inside one, four mechanics toiled over the fuselage of a biplane that had been stripped of its wings and was getting a new skin. In another not far distant, a group of men were "doping" a plane's exterior, giving it the first coat. Near by was a department where motor mechanics were engaged in overhauling an engine.

Major Royce escorted Pat from one place to another rapidly, for it was not his idea to weary the boy with

tedious explanations of each operation. He took him into the machine shop, one of the most completely equipped of the kind to be found anywhere. He went up a stairway to a loft where a number of men worked over parachutes. The life-saving devices were unfolded and checked every thirty days here, and the fabric was tested for possible weaknesses. Pat learned that twice a year each chute was given a regulation fall with a dummy from a fast-moving plane in order to make sure that it was in working order. They walked through the parts department where shelves and bins were stocked with all conceivable parts needed by planes. The captain in charge informed him that fully half a million dollars' worth was represented here.

Pat halted for several minutes in the photographic department because he wanted to add to the information he had already received from Mr. Kuenzel. Major Royce introduced him to Master Sergeant Rhodes who was directing the making of a mosaic. Small pictures that had been taken with a vertical camera were being fitted together, one overlapping another, until they made a perfect map such as might be obtained by focusing a camera directly downward. In response to Pat's request Sergeant Rhodes brought out the camera. He swung open a little compartment on one side and showed the boy the automatic recording apparatus, whereby was written on the outside edge of each picture the hour, minute and second that it was taken, the level position of the camera at the time, the exact altitude,

the number of the exposure, the focal length of the lens, and, in addition, the day, month and year.

"Once this is set in motion, it will map automatically a strip of ground ninety-one miles long by two miles wide," said Sergeant Rhodes. "The camera can be kept level despite the flying position of the plane. Signal lights flash to the pilot, warning him that pictures are being taken so that he can coöperate by steadying his ship and keeping it as level as possible. And it is fireproof."

Another place where the boy lingered longer than elsewhere was in the hangar where machine guns were repaired and overhauled. He had never seen one of those deadly weapons before, although he knew from his reading that a pilot fired it between the blades of the propeller, the gun and prop being synchronized so that the bullets were ejected between revolutions.

Back at last in the Operations Office, Pat found the planes were still in the air. The major suggested that he sit down beside the desk so that they could talk comfortably, and after Pat had done so, turned the conversation easily toward the subject of army flying.

"If you choose the army road," said the major, "there is a certain definite procedure for you to follow. You must be between the ages of twenty and twenty-nine years and must have at least two years of college work or the equivalent thereof. And," he added with a smile, "you must be unmarried. Those are the preliminary qualifications. You send in your application to the

Adjutant General at Washington, D. C., and if it gets favorable action, you submit yourself to a physical examination."

"I know that a fellow has to be physically fit before he can get in," said Pat.

"The physical examination is exhaustive. Besides the regular routine, the doctors test your flying sense. The effect of the various evolutions of flying on you is determined. You are whirled about, dipped forward and over and over. That's just one of the ways to find out whether you are a natural-born flyer. If you are, you pass the examination and in due time are enrolled in one of the primary schools."

"That's Brooks Field, isn't it?"

"Or March Field, in Riverside, California. Down in Texas on the outskirts of San Antonio is the greatest air training school in the world. It's the nest where Uncle Sam's eagles are hatched. Besides Brooks Field, there is Duncan Field, the great intermediate depot; Kelly Field, officially known as the Advanced Flying School; and Randolph Field is being added."

"Kelly Field must be a great place."

"It's been called the 'West Point' of the air. Some of our most famous flyers, Colonel Lindbergh, Lieutenants Doolittle, Maitland, and Hegenberger, are among its alumni. When its graduates come to a field such as this, they are presumed to be ready for service, and our task is to develop them into leaders of experience and judgment."

"How long does it take to become a pilot in the army?"

"I can answer that better by telling you how much it costs. Our government estimates that it takes around twenty thousand dollars to train a military pilot, so you can see why Uncle Sam is a bit choosy about who is trained. The course takes a year to finish and it is satisfying to know you are being trained in what is regarded everywhere as the finest flying course available, not only in this country but anywhere in the world."

"Won't you tell me something about the planes that your flyers use?"

"Surely. You mean the pursuit plane, I suppose. It is a biplane with a short wing spread, and it is highly maneuverable. That type of wing construction is easier to brace. Take the Boeing F4B with its wing span of only thirty feet. It can climb to eighteen thousand feet in ten minutes and its top speed is two hundred miles an hour."

"Gee!" exclaimed the boy, "more than three miles a minute."

"That's why its construction has to be so sturdy. Another distinguishing point about pursuit planes is the necessity for vision in all directions. The fighter must be able to see. You noticed how the side of the cockpit is cut out on either side so that he can see the ground; how the lower wing is staggered back from the upper, so that he can see the ground ahead of the wheels when landing.

"You also noticed, perhaps, how his line of vision is about on a level with the upper wing so that he can see straight ahead. That is particularly important when it comes to firing, or looking about to locate an enemy. The nose of the plane and of the gun both point at the target so that the whole ship is really a powerful weapon. The pilot of a single-seater comes nearest to the knight of old. In time of battle he must have courage, the ability to shoot straight, and the knowledge to maneuver perfectly one of the fastest machines that man has ever ridden."

CHAPTER THIRTY-SIX

ON BECOMING A PILOT

THE planes hove in sight to the northeastward, returning from their maneuvers. Again Pat took his position by the window, fascinated by the spectacle of ten ships flying as one. They came downhill on the air together, and their landing wheels splashed the soggy surface almost at the same moment. One beside the other, they stretched away in perfect alignment at the end of their flight.

The pilots swung easily from their cockpits and strolled across to the Operations Office to attend a school on the lessons learned from the flight. After a brief examination Major Royce excused Lieutenant Callahan, thus giving him an opportunity for a further visit with Pat.

"Gee, Lieutenant," said the boy regretfully, "it's three o'clock now, and by the time I can get home it will be long past school time. Dad will be awful sore."

"Oh, is zat so?" grinned the lieutenant teasingly. "What would you say if I drove you into Detroit in my own little coupé? Would that save you any time?"

"Drive me in? Gee, I should say it would. But I don't want——"

"No excuses now, Pat. I got away from class so I could talk to you, and if you leave me I'll have to re-

turn. Besides, there's something I want to show you right on the way to your bus."

"What shall we talk about? The army?"

They stopped at the side of a snappy coupé parked to the right of the roadway. The lieutenant unlocked the door and motioned grandly for his young friend to climb in. Then he opened the door nearest the wheel and slid into the driver's seat.

"Not to-day, Pat. Let's save that for some other time. Besides, the major told you quite enough for one day, didn't he?"

"No, sir," answered Pat. "I'd like to hear some more."

"Then you'll have to come back again. I want to talk to you about becomin' a pilot. You young fellows seem to think flyin' is nothing but a life of thrills, loop-the-loops, and hops over the moon. Let me tell you, lad, it's real hard work. In the army, in the air mail, in transport, or wherever you are."

The sentries on duty at the main gate lifted the wooden barriers guarding the entrance to the field. Smoothly as a watch the rakish car slipped along the road that led toward the north-and-south arterial highway. Within a short time they turned to the left on the latter thoroughfare, with the town of Mt. Clemens just ahead.

"So far as thrills are concerned," the lieutenant went on, "there are plenty to be had in the air, even to-day. The pilot who flies the night mail plane over the

mountains from Cleveland to New York City through the dark in all kinds of weather has more thrills on some of his flights than any old-time pilot ever had."

Pat nodded his agreement.

"Now it's all part of the night's work, isn't it?"

"Yes. The modern pilot is the same kind of young business man you would find in any other line. He is not full of color like the old barnstormer with ridin' boots and leather coat; but he's a better pilot. He doesn't want to fly faster than anybody else in the world, but he does want to fly longer."

"I know he is. But what has made all this change?"

"Uncle Sam has had a lot to do with it. Plane equipment is strictly regulated. A high standard has been set so that the old gypsy flyer with his home-repaired plane has lost out. The day has gone when you could take some balin' wire and fix up a ship."

He paused, wondering if Pat was paying attention. The boy seemed to be following him closely.

"Flyin' itself has changed. It's become a business, the business of speedin' up business. It was just a novelty in the old days. Like the balloon ascensions."

"One of the pilots I talked with—Mr. Reed—told me something of what a pilot has to know to be one. It seemed like a lot."

"Yes. You know that a pilot has to think in three dimensions, horizontal, vertical, and lateral?"

Pat nodded.

"And he must keep his mind on a lot of other things.

There's the terrain. And then there's the weather. There's his ship. Each day it's something different. Flyin' a plane is never twice the same, even the same plane."

"Why does a good pilot have accidents?"

"It depends on what you mean by accidents. There's a lot of difference between a forced landin' and a bad crash. Ninety per cent. of the accidents you read about are due to errors in judgment on the part of the pilot. In each one there is a different combination of circumstances."

"Yes, sir. I know that."

"Airplanes don't come apart any more. In the old days the pilot had to worry a lot about whether his wings would fall off, and keepin' his gasoline from explodin'. But that's all past now."

"Flying isn't as hard as it used to be, is it?"

"Well, I could teach the average chap in one day so he could fly a plane off our field if the weather was mild, circle once or twice, and make a landin'. But that isn't flyin'."

"No, I know it isn't."

"You can teach a man to fly, but you can't train him what to do under all conditions. Only experience can do that. Even in the air corps almost half the men who reach Brooks Field never get to Kelly Field."

"I wish you would tell me the best way to go about learning to be a pilot."

"The best way, of course, is through one of the

military services. Either my branch, the navy, or the marine corps. But it isn't easy to get into them. The number of appointees is very limited. Next comes a good civilian flyin' school. Find one that has the approval of the Department of Commerce, and you're almost sure to get a good course."

"How long would it take me to learn?"

"That depends on what you mean. It might not take you very long to learn to drive your dad's car around the block, but you wouldn't call that drivin', would you? And, as I say, flyin' requires experience. The average student can learn to solo in ten hours of instruction."

"How old should I be?"

"I don't know any fixed rule. Professor Alexander Klemin of New York University has said that nobody should begin under eighteen; and twenty is perhaps the best age."

"How many hours of flying do I need to get a pilot's license?"

"To be a limited commercial pilot you need fifteen hours. If you want a transport pilot's license, of course, you will need two hundred hours. But in order to be a good pilot you'll need many more. There's no such thing as a 'pretty good' pilot. The foolproof plane has yet to be designed. It's the same with an automobile. This coupé is mechanically perfect, and yet look at the thousands killed each year by automobiles."

"Does a good pilot need any special qualifications?"

"Yes, Pat. He must have flyin' sense. He must know

the feel of his plane. He must have the ability to think instantaneously and then execute his thought, so that he won't 'freeze' at the controls in the moment of extreme emergency. He must be of the flyin' type."

The boy peered out the side window and saw that they had turned west on Forest Avenue.

"You said you wanted to show me something on the way into town," he reminded his companion. "Aren't we in town right now?"

"Yes. And the thing I wanted to show you is on this street. Here we are, now."

The lieutenant pulled up alongside the curb in front of a narrow two-story brick flat which bore the number 1120.

"This old house," he went on, "isn't much to look at, but to me it's a shrine, just as it is, I think, to every man who loves flyin'. Do you see that plate on the side of the porch? Get out and go over so you can read what it says."

Almost immediately Pat solved the mystery.

"Gee!" he exclaimed, a note of awe in his voice, "this is where Lindy was born."

He stepped over to the plate and read:

> This tablet marks the birthplace of Captain Charles A. Lindbergh. The first aviator to fly from New York to Paris was born here February 4, 1902. The son of Charles A. and Evangeline Lodge Lindbergh. After flying alone 3640 miles in 33½ hours May 20–21, 1927, Captain Lindbergh was

decorated by France, England and Belgium and Spain, and awarded the Distinguished Flying Cross by Calvin Coolidge, President of the United States.

"I brought you here," said his friend, as they pulled away and headed toward downtown, "so that I could emphasize something that I wanted you to read. It was printed originally in the New York *Sun* after Colonel Lindbergh made his famous flight, and I have saved it because it has been an inspiration to me and many another flyer."

While he guided the wheel with one hand, he extracted a leather wallet from an inner pocket with the other and handed it to the boy. Inside the first flap Pat found the *Sun's* tribute to the intrepid pilot who blazed the way to glory across the Atlantic Ocean.

Alone? Is he alone at whose right side rides Courage, with Skill within the cockpit and Faith upon the left? Does solitude surround the brave when Adventure leads the way and Ambition reads the dials? Is there no company with him for whom the air is cleft by Daring and the darkness is made light by Emprise?

True, the fragile bodies of his fellows do not weigh down his plane; true, the fretful minds of weaker men are lacking from his crowded cabin; but as his airship keeps her course he holds communion with those rarer spirits that inspire to intrepidity and by their sustaining potency give strength to arm, resource to mind, content to soul.

Alone? With what other companions would that man fly to whom the choice were given?

CHAPTER THIRTY-SEVEN

HIS FIRST JOB

MAY came at last. Just around the corner was June—vacation time. The grass glistened along the fairways and on the greens, and the click of lawn mowers once more echoed from rolling expanses of hill and rough. Pat's irons shone like silver, and his drives and putts were better than ever. All his fellow caddies predicted victory for him in the tournament by a big margin.

One evening, just as he finished his arithmetic lesson for next day, the telephone bell jangled. It was Mr. McDonald. The boy had not heard from him for some months, although he had seen him occasionally on the links.

"Hello, Pat. How's the flying bug? Still as lively as ever?"

"Oh, hello, Mr. McDonald. Yes, sir. Only I don't have much time now to go down to the airport."

"What are you planning to do this summer when school lets out? Caddy again?"

"Yes, sir."

"How would you like a job at the airport?"

At his words Pat's mouth gaped open; he began to stutter excitedly.

"Would I? Say, Mr. McDonald—gee!"

"Well, I think you can get one. Stan Knauss called me up to-day and asked me to give you a message from him. He wants to see you some evening after school. Confidentially, he told me that if you really want to learn how to fly he's willing to start you on the road."

"Gee, Mr. McDonald, I'll go down to the terminal right away—first thing after school to-morrow night. Do you think he means it? That I can get a job there?"

"Sure. But it all depends on your talk with him. You've got to sell him on the idea, Pat, so make a good job of it."

Pat did not forget his friend's advice. When he faced Mr. Knauss on the next afternoon he sold the idea so thoroughly that the job was his. On the day after school closed for the summer, he reported at the terminal to begin work.

So, if you happen to be in Dearborn in the vicinity of the airport and visit the terminal depot during the vacation season, you will probably see Pat lugging suitcases, sweeping the floors, or doing odd tasks that might seem menial except to a devotee of aviation. To him no task is too menial that has started him on the flying road.

The Birch Hills Country Club has lost its champion caddy.

THE END

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